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THAMES BARRAGE

With the possibility that a decision may soon be taken on the proposal for constructing a surge-preventing barrier across the Thames, discussion of the wider pre-war controversy about the merits of a Thames barrage, which would form a tideless river through London, is now particularly timely. We were, therefore, very interested to be able to print the views of the Port of London Authority's Chief Engineer, Mr. G. A. Wilson, in the letter published in our issue of July 12.

It is not our intention to list the advantages—which are many—of the barrage scheme, or to balance them against the difficulties set out by our correspondent. Such a course would inflame rather than resolve this controversy. Ever since the barrage was first proposed the Authority has opposed it. But when engineers have been at loggerheads over a scheme for so many years, an examination of the "factor of ignorance" which divides them may be worth while. The present situation may be summed up as follows: it is proposed to build a barrier to stop storm surges flooding London. For this purpose it would be closed only very rarely, and it is difficult at present to visualise it as other than an expensive expedient; nevertheless, this one function justifies it. The same function, however, could be performed by a barrage which permanently raised the river level upstream, and shut out the tides and salt water altogether. This second project raises a host of other issues, of considerable complexity. Probably the greatest single issue is the way in which ships could be "locked" through the barrage, which could be accomplished, but perhaps not accomplished economically, even if some novel engineering solution were put forward.

The River Thames fulfils many and varied functions. Its improvement—economically and æsthetically—is an important matter; sufficiently important in our view to merit a thorough engineering investigation of the "barrage" as well as the "barrier." Let a barrage scheme be planned, we suggest, by a group of engineers who are enthusiastic and will put their best into it and will make a practical job of solving the difficulties in detail. Then let an appraisal of costs and benefits be made between the two schemes, including accounts of all the "conversial" factors. Only in this way will the controversy be settled, and only in this way will all the riparian interests be given due weight. A great deal has been found out about the river already. It would be a pity to stop short at a purely utilitarian solution of restricted value, the "barrier," without determining for certain the practicability of a much more inspired concept, the "barrage." The scale of the problem is large enough to justify amply such a course; the extent of the research already put into investigating the behaviour of the estuary reinforces it, by presenting new knowledge which can be applied to an objective solution.

ANCIENT AND MODERN

It is a pleasing characteristic of human beings that when a prominent structure of some age is threatened with destruction people leap to its defence. Indeed, this quality in the human mind, this desire to preserve the old and ancient, seems so innate in all of us that it has led to the creation of numerous societies whose objects are the prevention of destruction. An example of this action and reaction has lately been provided by the publication of proposals for rebuilding Albert Bridge across the Thames in London, a familiar landmark to all who live in Chelsea on the North Bank and Battersea on the South and well known to many other Londoners. The London County Council wishes to pull it down because it is unsuitable to carry heavy loads such as lorries and buses; Chelsea and Battersea people wish to preserve it because it is familiar and because it is regarded as graceful; and many an engineer would like to see it preserved as an example of a kind of bridge which will never be built again and which indeed is something of a technical curiosity. How should such problems be resolved? We do not propose to discuss here the ins and outs of the particular problem of Albert Bridge. More information about the amount of traffic carried by that bridge and the two other bridges, Chelsea and Battersea, not far away, is needed for a correct assessment; and there have to be weighed in the balance longer-term plans for the development in general of cross-river routes in the London area. We wish rather to write in more general terms. How ought we to balance the advantages of preserving something beautiful, or unusual, or of technical interest or merely ancient, against those of replacement by something more suited to present-day needs?

To start with we must reveal ourselves as ruthless. The right place for things that have outlived their original purpose is a museum. If they are too large; or unsuited for carriage to a museum; or if there is no space for them in a museum, then, if they stand in the way of modern development, they must be destroyed. The reason why so many Georgian houses have survived from the past is not because they are architecturally delightful but because no age since has produced more comfortable homes. But it is to be noted that few,

if any, of them have been preserved as a museum piece would be preserved. Modification has been necessary. Modern bathrooms, modern kitchens, modern lighting and modern plumbing has been imposed upon them. Moreover, were modern architects able to design new houses markedly superior in comfort, convenience and beauty to the Georgian, our Georgian squares and terraces would revert to slums as quickly as the new houses were built and a demand, that no preservation society could hold back, would arise for the demolition of those same squares and terraces to make room for the new ! One cannot lead a modern life in a museum piece ! Mechanical engineers are, of course, quite used to this ruthlessness. Old and heavy machinery still quite serviceable has to give way to the new and go to the scrap heap. It is only seldom that it can be preserved *in situ*, creating for itself, so to speak, its own museum, as has been done with certain engines in Cornwall. More usually it would be in the way, an encumbrance. Only if it is very notable—or if less notable, of convenient size—can there be justification for the expenditure of money upon its removal and re-erection appropriately in a museum. Electrical engineers, in so far as their heavier plant is concerned, have hardly faced the problem yet. But it is far from improbable that at some future date there will be a demand for the preservation intact of some particularly notable power station ; and will the public forty or fifty years hence view with complete equanimity a proposal to demolish Calder Hall ? Most of all, civil engineers encounter the problem. There is scarcely ever an old bridge threatened with demolition or even a railway or a canal threatened with abandonment that does not call people to its defence. Sometimes—fortunately—the difficulty can be evaded. The old bridge, too narrow or too unsound to carry modern traffic, can be preserved to carry minor traffic whilst the heavy traffic is diverted to a new, modern bridge sited, more conveniently for modern needs, some distance away. The old railway can be preserved as a modern footpath like the Manifold line in Derbyshire. A new use may be found for parts of an abandoned canal. Any ancient structure even though past all use, so long as it is sited in a way that imposes no handicap on modern development, can be and should be preserved. This generation would, indeed, be lacking in its duty to those to come if it did not so preserve them. But this benevolent toleration of the ancient and unserviceable cannot be extended to cover structures that stand in the way of improvement. At some distant time in the future we can foresee a possibility that Paddington will be abandoned as a railway station. Can we really believe—unless some new use can be found for the space beneath—that the famous roof will be permitted to survive ? It was not the failure of a pier of the old Waterloo Bridge in London that led to its demolition. Sooner or later a much wider bridge would have had to replace it. It stood as a handicap to the development of London as a modern city. Incidentally, the bridge that replaced it marked a notable advance in the structural design of concrete bridges. Much of the objection to the demolition of old and familiar structures arises, we suggest, from a lack of faith in the powers of our generation to replace them with something having as much character and beauty as the old. We should have more faith in our own generation !

BRITAIN'S DETERRENT WEAPONS

When the successful results of the Christmas Island tests have been analysed, the way should be clear for implementing the policy laid down in the 1957 Defence White Paper. Indeed, it is not clear to us how those who opposed the tests could at the same time approve the White Paper, since the two are interdependent. The deterrent already built up in this country—a force of V-bombers armed with atomic bombs to be dropped over the target—has become inadequate, if not wholly ineffective, since the development of the thermo-nuclear explosive and the anti-aircraft guided missile. There is, however, good reason to believe that the British Government has delayed the production of a " stand-off " guided bomb, which would be launched from bombers well outside the range of anti-aircraft guided missiles, until it was sure that it could produce the thermo-nuclear explosive required for it. The air-to-ground guided flying bomb is no new thing. The U.S. Air Force has already in prospect a missile of this kind—the Bell " Rascal " GAM-63—which powered by a three-cylinder rocket engine has a range of about 100 miles and a maximum speed of Mach 1·5. A flying torpedo—the " Petrel "—is now in use by U.S. naval aircraft for firing at ships. The guidance systems—as is now clear from recent official announcements—no longer present difficulties for British firms. They have already in production four types of anti-aircraft guided missiles, the ground or surface-to-air " Sea-slug," " Thunderbird " and " Bloodhound," for the Navy, Army and Air Force respectively, and the air-to-air " Firestreak." There thus seems no reason to anticipate any major difficulty in manufacturing the heavier and larger " stand-off " guided bomb now that the explosive is available.

The policy outlined in the Defence White Paper covers a period over the next five years, by which time we may expect to be receiving the intermediate ballistic rockets promised from the United States. To judge by present progress, the bomber—with or without its " stand-off " bomb—may well have given place as the main deterrent to the intercontinental guided flying bomb and the intermediate-range ballistic rocket. In any event it is not too early to consider what use we are to make of the rockets received from the United States. The U.S. Army and Air Force intend to use these 1500-mile rockets as a bombardment weapon from overseas bases. But special attention is being devoted to the naval version—the " Polaris "—and U.S. ships are already being converted for test launchings in about eighteen months time. The United States Navy is also developing a small ballistic rocket with a range of 650 miles for firing from a submerged submarine and one may assume with confidence that Soviet submarines will be equipped to use a similar missile, as well as guided flying bombs. The Russians are known to have rockets with a range of 800 miles, which could reach this country from Soviet occupied territory, and they are not building 700 submarines by 1960 unless these underwater vessels are to have some useful purpose in a nuclear war. As far as Britain is concerned, the I.R.B. rocket is clearly a naval weapon. Launched from bases in Britain, they could not reach vital targets in Eastern Russia. Much may happen in the next five years. But rather than sell our older slow carriers to foreign nations, we would do well to earmark them—and suitable merchant ships—as rocket firing ships, and to prepare plans for their internal reconstruction to accommodate a worthwhile number of these large rockets.

Building up the deterrent must not, however, blind us to the need for being instantly ready for the much more likely limited or local war. The Suez operations should be a lesson to us. The decision in 1955 to concentrate on nuclear weapons resulted in a sharp reduction in the number of ground troops, landing craft and other essential forces available in Britain. At the end of last July, when Nasser antagonised the western world by his nationalisation coup, we were unable to occupy strategic points in the Canal area. And even after a two months' build-up of our forces we did not feel strong enough to fight an enemy, known to be of very inferior fighting quality and having already suffered a heavy defeat, until five days had been spent in eliminating his air force. We thus lost goodwill and prestige and failed in our political objective—the safeguarding of the Canal. The formation of the new Central Reserve Brigade Group should make us better prepared to meet emergencies of this kind. But it must be kept up to strength, with adequate air transport always available and modern carriers and cruisers to provide air and artillery support in the early stages.

A Seven Day Journal

The Roads Programme

IN a debate on the roads programme, in the House of Commons on Monday, the Minister of Transport and Civil Aviation, Mr. Harold Watkinson, said that over the next four years it was proposed to put in hand road improvement works which would ultimately cost the Exchequer about £240 million. That, he commented, was a very considerable advance on anything this country had so far done on roads. The Minister went on to say that the £240 million was the cost of doing what he wanted to do, namely, to keep the pipeline of road schemes full and thus obtain the maximum rate of actual road construction. That, he added, was what was wanted ; there had been too many plans in the past which had not been implemented. The programme, Mr. Watkinson continued, was subject only to one thing, something to which all capital investment programmes were subject, which was that the country's economy was " prosperous and buoyant enough to stand it."

Earlier in his speech the Minister said that he had set up a small planning section in his department which was considering roads over a cycle of twenty years and was trying to do all the " slide-rule calculations about increased traffic." What was being attempted was a specific three-point plan for the immediate future. That plan was to try to make a start on a major network of trunk roads, many of them built to motor road standards ; to clear away urban bottle-necks, and to try also to have a reasonable amount of smaller works all over the country which would make a contribution to the solution of specific problems in specific places.

Bradwell Power Station and Beyond

AT a press conference in London last week Sir Claude Gibb, chairman and managing director of the Nuclear Power Plant Company, Ltd. (N.P.P.C.), gave a brief progress report on the nuclear power station which this company is building at Bradwell-on-Sea, for the Central Electricity Authority. In the six months since work began on the site 255 sub-contracts have been placed by N.P.P.C. and its member companies, and work is now in hand on orders worth about £17,000,000. A large proportion of the total cost of the station, about £40,000,000, is to be expended on sub-contracts by over 1000 British firms.

Commenting on the present rapid pace of technical progress in the application of nuclear power, Sir Claude explained that, for the practical purpose of submitting a tender in the autumn of last year, it had been necessary to " freeze " the Bradwell design in November, 1955, for a station with a guaranteed electrical output of 300MW. To-day, using existing knowledge, it would be quite practicable to design a station with an output at least 30 per cent greater than that of Bradwell, at a capital cost only 15 per cent greater. So great were the realisable potentialities of the gas-cooled graphite-moderated reactor that Sir Claude was confident it would hold the field, certainly in Great Britain, for at least the next fifteen years. He agreed that the number of likely foreign customers for complete reactors of this kind was limited, but he felt that there was a considerable market for reactor " know how." If this " know how " was to emanate from Great Britain, with her limited manpower, it could only be done by concentration of effort, for the present, on the graphite-moderated reactor instead of dissipating the available resources amongst a number of alternative projects.

Sir Claude emphasised the need for improved load factor as a means of off-setting the comparatively high capital cost of nuclear power stations. In Ontario, for example, about 75 per cent of the electrical generating plant was running continuously, compared with only about 25 per cent in Great Britain. In his company's Newcastle factory Sir Claude has practised his precepts by installing 4000kW of under-floor off-peak space heating (without the incentive of attractive night tariffs) with the result that the night load is about 15MW and the day load about 11MW.

The Engineer
100 Years Ago
(JULY 24, 1857)

" AERONAUTICS "

" Several of our recent correspondents seem to take considerable interest in this subject, but so far we have been unable to see that anything new has been elicited. They are going over ground which has been well traversed many years ago. We have little to say, but merely propose to indicate what appears to be the direction which investigation should take in order to arrive at anything like a useful result.

" And in the first place, we believe the navigation of the air to be perfectly practicable, and that by arrangements long since given to the world. What is said by some of our correspondents about the action of side winds and the use of sails, shows very mistaken notions about the state of matters aloft. The air-ship, after parting company from mother earth, will experience a perfect calm, unless its own propelling power is being exerted. When it is being propelled *through* the air, of course those on board will experience the sensations of a current of air moving in the opposite direction to it. If the air moves, the air-ship will move with it, and at the same speed ; but unless self-propelled *through* it the air-ship will not be exposed to a breath of wind. The action of the wind is felt on the earth, because whilst the air moves, the earth is stationary ; but if the earth moved with the velocity and in the direction of the wind, as happens with the air-ship, no effects of wind would be experienced on its surface. . . .

" A great many points can be settled by calculation, but reliable experimental data are wanting as a basis. The field is open to those who have the time, the money, and we may add, the courage ; and if such exist, they may feel assured their labours will not be without interesting if not useful results."

High-Altitude Research

AT the High-Altitude and Satellite Rocket Symposium, organised by the College of Aeronautics, the Royal Aeronautical Society and the British Interplanetary Society, and held last week at the College of Aeronautics, the leader of a group of observers from the Academy of Sciences of the U.S.S.R., M. Boris M. Petrov, spoke of the Soviet programme of researches in the International Geophysical Year. He indicated that as many as 125 research rockets would be fired in three different zones. It was planned to place a satellite in an orbit passing near the poles, and this would be done at the time of a " World Day."

Among the papers read last Friday was one by Dr. P. Murray, of A.E.R.E., Harwell, on " Materials for Re-Entry Vehicles " ; because of the poor mechanical properties of insulating materials, it was concluded that bulky insulation on a metal structure would be required. Lieut.-Colonel J. P. Henry, Biosciences Division, European Office, U.S.A.F. Air Research and Development Command, spoke on the " Psycho-Physiological Hazards of Space Flight." He showed that if men were deprived of changing sights and sounds and of the feel of their weight, they would be severely impaired in temperament and even suffer from hallucinations ; while these effects might be harmless in the laboratory, that would not be true of a man whose life depended on his own decisions and actions. These effects could set in in a few hours, and it was necessary to keep crews " warmed up " with a supply of meaningful information.

Gatwick Airport

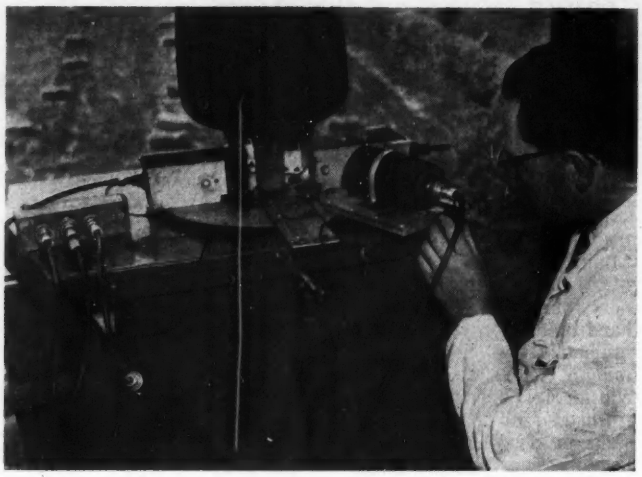
ON Monday last, the Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, Mr. Airey Neave, visited Gatwick Airport to inspect the development of Gatwick Airport. The work at present in progress represents stage I of the modified proposals, and is confined to the southern E–W runway (see article and map on page 140, July 31, 1953). On Thursday next, August 1, the diversion of the London–Brighton Road, A.23, to pass by Gatwick Racecourse Station, will be opened ; near the station the road is divided into two carriageways and from each a ramp leads up to the passenger terminal above the road. A feature of the terminal is that outbound passengers and their luggage pass through customs separately, only when proceeding to the aircraft in the case of passengers. The terminal is provided with long enclosed " fingers " to shelter passengers walking to and from the aircraft. Supporting columns are being built at this stage to allow an office block to be added above the flat roof of the terminal, which is to be open to spectators. The flying control building is over a mile away, halfway along the runway and to the north of the taxiway, and shares its site with the fire station. The 7000ft by 150ft runway is given a dark surface by dispersion of carbon black in the concrete ; it is laid in 15ft square slabs, load transference being by embedded bars in the case of longitudinal joints, high-tensile steel being used where aircraft movement is across them. The concrete is laid on a polythene slip membrane.

On the occasion of this visit we made a brief tour of the site. The pavements of the new road were virtually complete, and parts of the terminal building were being decorated. The control tower also was well advanced Laying of concrete taxiways and runway was in progress. A central mixing plant was in use, the mix being carried over the site in 4-yard batches by large " Sussex " tippers. Spreading was by machine, except for the endowment of high skid resistance on the surface by hand brushing, immediately before sealing the surface with rosin. Joints were being sawn in the concrete already laid.

Research into Boiler Circulation Theory

No. II—(*Concluded from page* 83, *July* 19)

Co-operation between the Water-Tube Boilermakers' Association and Cambridge University has led to the erection of the research equipment. Its object is to establish experimental data about the pressure drop and flow conditions of a steam-water mixture flowing along heated and unheated pipes up to the critical pressure of steam. There is seen alongside the rotating head at the outlet from the test-section.



Temperature Measurement.—In any scientific research it is essential that the selected methods of measurement give results with the highest degree of accuracy. In this present work it is most important to measure accurately the difference between the temperature of the water at test-section inlet and that in the drum, thus ensuring that the water enters the test-section at a temperature as close as possible to its saturation temperature. It was eventually decided to measure this temperature difference directly by two thermo-couples connected differentially, so that the wires of each thermo-couple must be electrically insulated from the sheath in which they are carried. This arrangement introduced difficulties which had to be solved before a design capable of withstanding the pressure, yet of sufficient accuracy and sensitivity, was obtained. In the final design, the couples were made from chromelconstantan wire since it gave the highest e.m.f. for any specified level of temperature, the wires being continuous from hot-junction to cold-junction.

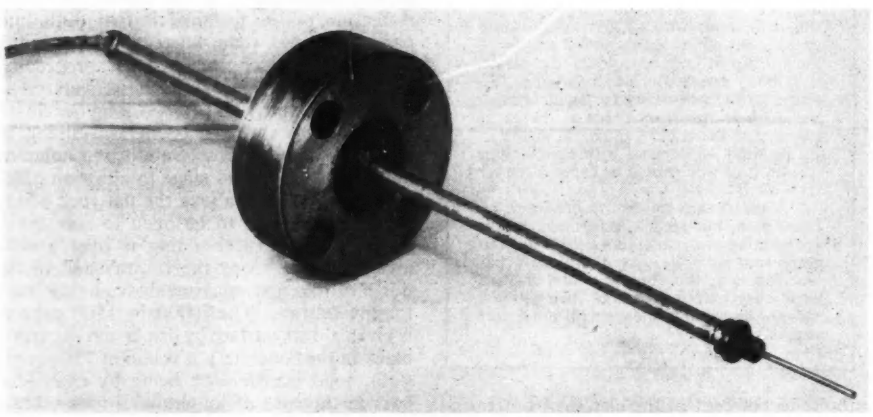


Fig. 10—High-pressure differential single point thermo-couple

Before the final design—Fig. 10—was evolved, and in order to obtain rapidity of response to temperature changes, a number of alternative constructions were investigated, and their response curves are shown on a drawing—Fig. 12. The design adopted approximates to that shown as type 9 on this drawing, but the couple wires are not welded to the tip of the sheath, high sensitivity being obtained by making the extremity of the sheath of thin-walled stainless steel tubing. It is consequently believed that, as a result of this development, the temperature difference recorded by these couples will be reliable to approximately ½ deg. Fah. over the range of temperature levels encountered on this plant.

A further interesting development is the use of triple-junction differential thermo-couples—Fig. 13—to measure the temperature rise of the cooling water flowing through the coils of the induction heating units. The cooling water, which is circulated to maintain the copper tubing at a safe temperature level, carries away the major heat loss from the heaters, and its rise in temperature must, therefore, be accurately measured if the useful heat input over the heated length of the test-section is to be known with certainty. This temperature rise is less than 10 deg. Fah., and the accuracy of measurement of the difference is greatly increased by the adoption of the triple-junction differential thermo-couples.

Pressure Measurement.—In order to ensure that the water entering the test-section is as close as possible to its saturation temperature, it is essential that the change in pressure between that point and the drum be accurately established. Pressure drops resulting from the flow of the fluid between various parts of the experimental plant are also measured. All of these measurements are taken from either a direct reading mercury or igema manometer, both of which were designed and manufactured in the Engineering Laboratory. These meters replaced, for accurate work, the commercial differential pressure meters which were fitted at the outset, and which for various reasons have never given satisfactory service. The construction of these new manometers is illustrated in Figs. 11 and 14. A slab of "Perspex" is sandwiched between steel plates and the whole drawn together by through bolts to resist the internal pressure. The mercury or "Igema" fluid is contained in a glass pipe recessed into one of the steel plates. The glass pipe is subjected only to the differential pressure under measurement the interior of the pipe being connected to one measuring point and the outside to another. A vee-notch cut in the "Perspex" deflects a beam of light from a light source on to the glass tube from which light is reflected by the other side of the vee-notch towards an observing telescope. Owing to the presence of the bolts the level of the fluid cannot always be observed. The difficulty is overcome by placing a float in the tube—Fig. 15—having two measuring marks upon it at a known spacing differing from that of the bolts. One of these manometers has been satisfactorily tested up to pressures beyond 4000 lb per square inch.

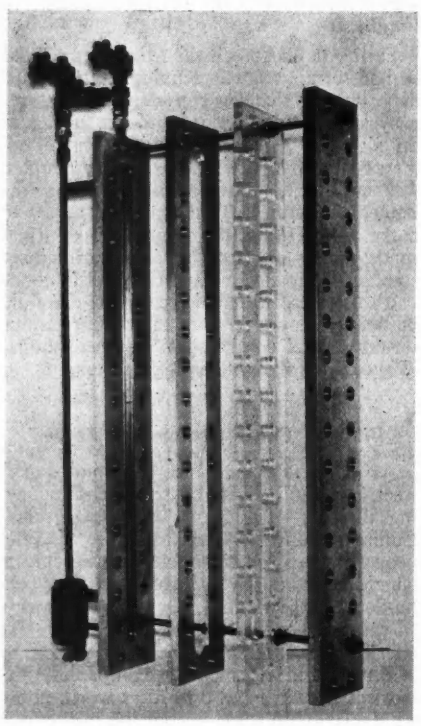


Fig. 11—High-pressure differential pressure manometer. The parts of the manometer are seen separated but in the correct relative positions

Density Measurement.—To investigate the possibility of "slip" the Atomic Energy

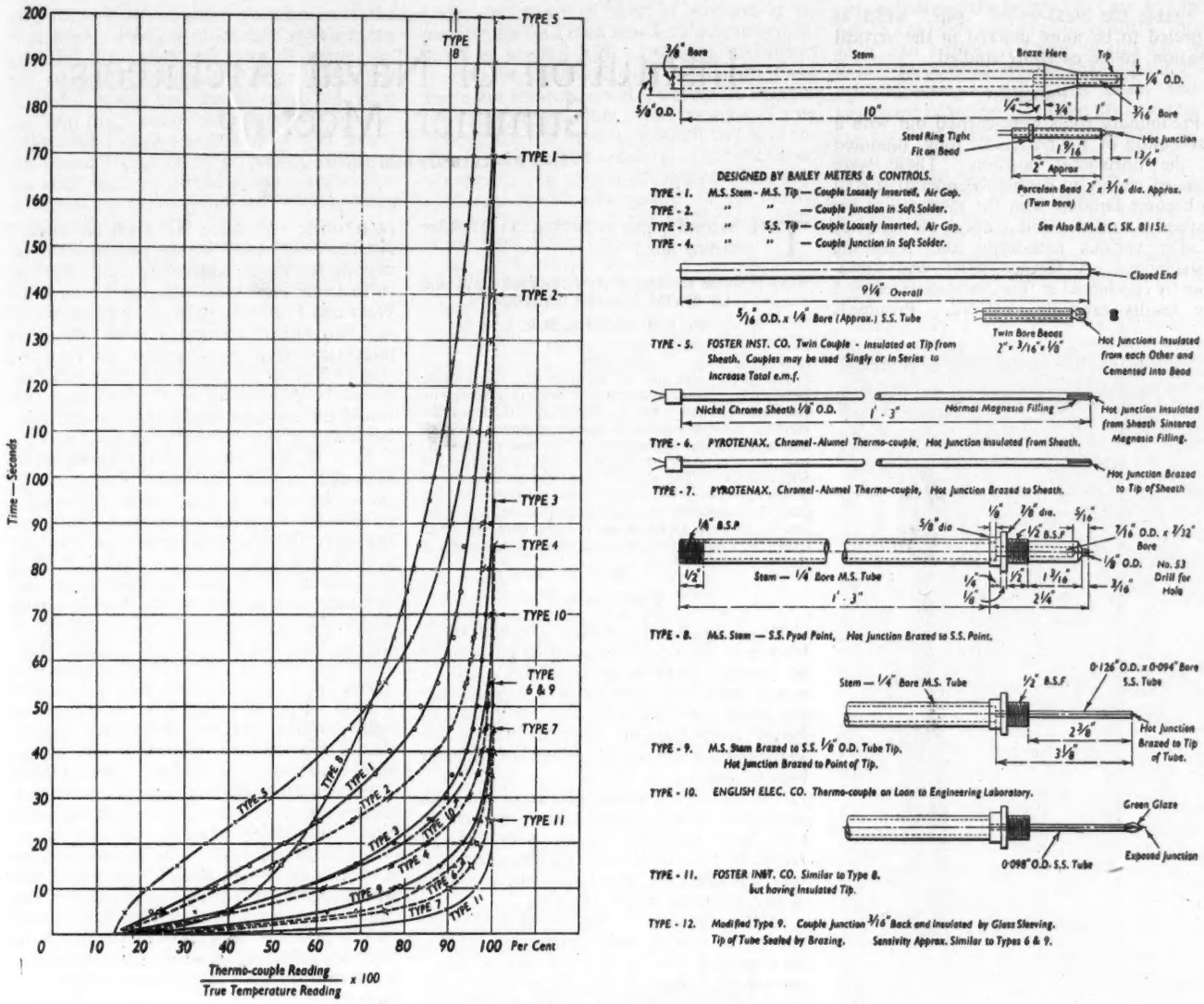

Time — Seconds
Thermo-couple Reading / True Temperature Reading x 100
Per Cent
TYPE 5
TYPE 18
TYPE 1
TYPE 2
TYPE 3
TYPE 4
TYPE 10
TYPE 6 & 9
TYPE 7
TYPE 11
DESIGNED BY BAILEY METERS & CONTROLS.
TYPE - 1. M.S. Stem - M.S. Tip — Couple Loosely Inserted, Air Gap.
TYPE - 2. " " — Couple Junction in Soft Solder.
TYPE - 3. " S.S. Tip — Couple Loosely Inserted, Air Gap.
TYPE - 4. " " — Couple Junction in Soft Solder.
See Also B.M. & C. SK. 81151.
TYPE - 5. FOSTER INST. CO. Twin Couple - Insulated at Tip from Sheath. Couples may be used Singly or in Series to Increase Total e.m.f.
TYPE - 6. PYROTENAX. Chromel-Alumel Thermo-couple. Hot Junction Insulated from Sheath.
TYPE - 7. PYROTENAX. Chromel-Alumel Thermo-couple. Hot Junction Brazed to Sheath.
TYPE - 8. M.S. Stem — S.S. Pyod Point. Hot Junction Brazed to S.S. Point.
TYPE - 9. M.S. Stem Brazed to S.S. 1/8" O.D. Tube Tip. Hot Junction Brazed to Point of Tip.
TYPE - 10. ENGLISH ELEC. CO. Thermo-couple on Loan to Engineering Laboratory.
TYPE - 11. FOSTER INST. CO. Similar to Type 8. but having Insulated Tip.
TYPE - 12. Modified Type 9. Couple Junction 3/16" Back and Insulated by Glass Sleeving. Tip of Tube Sealed by Brazing. Sensivity Approx. Similar to Types 6 & 9.

Fig. 12—Response curves of thermo-couples

Research Establishment at Harwell supplied on loan a gamma-ray device to the Department of Engineering. In this device a beam of gamma-rays from a radioactive source is passed through a short length of high tensile alloy steel tube, which is connected to the outlet end of the test-section. The alloy steel tube enables more sensitive readings to be obtained from the device by reducing the wall thickness of the pipe and thereby its screening effect. Originally the source consisted of a 1mm by 1mm capsule of iridium 192 having a strength, when new, of about 40mc and a half-life of only seventy days. This has now been replaced by a 2mm by 2mm source of cæsium 137 of similar strength, but with a half-life of thirty-three years. The source emits radiations in every direction, and when the test section is in the vertical position some of the radiation passes through the pipe and its contents. The emergent radiation, which is a function of the density of the contents of the pipe, is measured in an ionisation chamber at the opposite end of the diametral axis. The current flowing through the chamber is related to the amount of radiation received, and this current is fed to an electrometer designed for measuring direct currents in the range 10^{-8} to 10^{-15}A. For convenience and safety it is desirable to use a weak source, and the sensitive ionisation chamber and high-magnification electrometer enables this to be done. However, to improve even further on the sensitivity of the device, a secondary or "backing-off" ionisation chamber is fitted. The use of this chamber indirectly enables the very small changes in the ionising current resulting from changes in the density of the fluid to be magnified and more easily measured. The working head is seen in use in the title picture, page 112.

The measurements obtained from the use of this equipment, together with a knowledge of the flow rate and heat input in the test-section, enable the respective velocities of the steam and water phases at the scanning point to be estimated. The velocities thus calculated are "average" values, and provide means of estimating the respective pressure drops due to acceleration and wall friction. In addition, a knowledge of the mean density is particularly valuable when the test-section is in the vertical position. Two more of these devices are to be mounted on the vertical test-section at the 8ft and 16ft levels

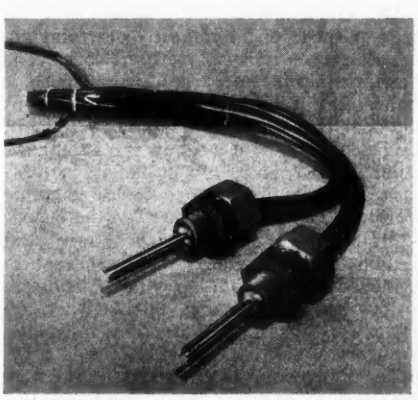


Fig. 13—Differential triple point thermo-couples for cooling water circuit to induction heaters

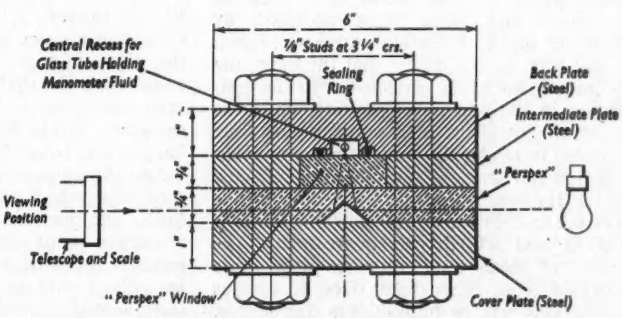


Fig. 14—Direct reading manometer for high working pressures

to enable the build-up of "slip," which is expected to be more marked in the vertical position, to be carefully studied.

Progress

Preliminary trials were carried out with a test-section of 1in bore, 24ft long, mounted in the horizontal position. These were planned mainly to enable the operating staff to become familiar with the response of the respective controls, and to check the accuracy of the various measuring and recording instruments. A further series was subsequently conducted at four pressure levels and the results carefully analysed. Proposals

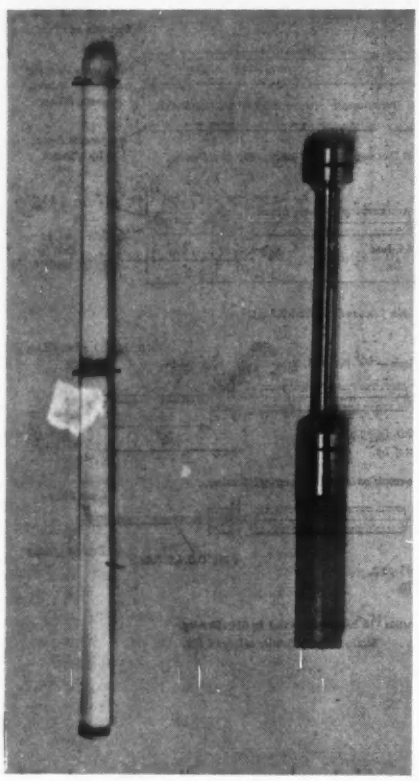


Fig. 15—Types of floats used in high-pressure manometer. That on the left is suitable for "Igema" fluid, that on the right for mercury; note on both the duplicated measuring marks a known distance apart

were made for improving the operation of the experimental plant—by effecting certain refinements to the equipment and operating technique—and these were accepted by members of the Technical Advisory Panel. It had been agreed earlier that the operating technique should be perfected with the test-section in the horizontal position, since the gravitational effects in a vertical pipe were expected to render the analysis more difficult. The first full series of tests was then effected on the 1in bore horizontal test-section at five pressure levels, namely, 250 lb, 600 lb, 1250 lb, 2100 lb, and 3000 lb per square inch. The results of these tests, together with those obtained from other tube sizes at various inclinations, will be published in due course.

Mechanical Stokers for B.R. Locomotives.—Five British Railways standard 2–10–0 steam locomotives are to be fitted with Berkley mechanical stokers, in order to determine to what extent they can haul heavier loads of continuously braked wagons at the higher speeds required under the modernisation plan. At present, with manual firing, the normal maximum number of loaded 16-ton mineral wagons that these engines can haul at the overall average speeds required by class "C" schedules (i.e. up to 42 m.p.h.) is 37, whereas it is thought possible that with mechanical stoking the load may be increased to fifty-three wagons.

Institution of Naval Architects Summer Meeting

No. II—(*Continued from page 90, July 19*)

THE second paper presented on Tuesday morning was :

TUG POWER IN RELATION TO THE TOWAGE OF SWIM ENDED BARGES

By J. B. Griffith, B.A.

Synopsis

The paper sets out to examine the relationship between tug power and speed of tow in lighterage on the River Thames. Special points are made of the method of measurement of speed and power on trials and the need for uniformity in the type of craft on tow, to enable data for one set of trials to be compared with another. The author shows the great waste of power inherent in the conventional method of towing craft and suggests a considerable saving would be possible if pairs of barges in the tow could be effectively held apart, thus bringing about a reduction in the interference effect.

Discussion

Mr. A. G. A. Muirhead : The method of towing on the River Thames does not seem to be repeated in many ports of the world. I would like to call attention to a very interesting paper published by the Institution of Naval Architects in 1945, in which was suggested an improved design of Thames tug and barge.

I should like further details of the tug, illustrated in the paper, which appears to have been designed to suit a draught of 7ft 9in aft ; we understand the draught varies very considerably, and I ask whether there is any difference in the efficiency.

In the elevation of the tug shown in the paper, the towing hook appears to be very high up and very far aft. In view of that I ask whether the stability of the tug is sufficient, whether stability is improved and, inasmuch as the hook is so far aft, what are the handling characteristics ?

Mr. J. Burton Davies : When describing the method of towing barges the author mentions that the reaction of the propeller race on the swims of the leading pair of barges is accentuated by the fact that the vessels are generally designed to meet stringent limitations in draught. In a paper entitled "Resistance of Barges in Deep and Shallow Waters," by the late Dr. Allan and Mr. Walker (*Trans., I.N.A.*, 1948), the criterion for shallow water was taken as $V^2=3$ times the depth of water in feet, and it was also shown that the shallow water increment was very susceptible to the ratio depth of water/draught. While the speed at which Thames barges are towed is probably, in general, below this criterion, I should think that the ratio of depth of water/draught is often very low. The previous paper I have mentioned showed a rapid rise in shallow water increment at ratios of about two and a half and less, which, with the barge used for the present tests, would correspond to a depth of water of 20ft or less. Could the author say for what conditions the tank tests were carried out—deep or shallow water ?

I refer to the statement that the interference effect was reduced when barges being towed alongside were held 9in apart. The section shown in Fig. 3 of the paper shows that the sides of the barge are at an angle to the vertical, and I presume that the distance apart of 9in is at the deck level and not at the waterline. Would the increase of the angle of the sides and the lashing of the barges close alongside each other still have a beneficial effect ? Alternatively, what would be the effect of making the barges absolutely wall sided and still lashing them close together ? Some ten years ago Professor Baier, in a paper to the A.S.N.A.M.E., advocated the maximum integration possible. Of course, he was referring to flotillas far larger than anything that would be practicable on the Thames ; but would the same principle apply to the swim barge ?

Ir. J. H. Krietemeijer : The author states that there is little published information for the owner who is faced with requirements outside his experience regarding the power necessary for new conditions. In this connection, I would like to compare the towing of Thames barges with the quite dissimilar methods used on the Mississippi or on the Rhine. Compared with the Thames tows, the tow on those other rivers is much bigger. Assuming that the Thames barge can load about 250 tons, a tow of six barges represents a load of 1500 tons. On the Rhine the lighters sometimes load 3000 tons each, so that a tow of four lighters in line gives a total load capacity of 12,000 tons. On the Mississippi the powered vessel is astern, and pushes the set of barges, the load being sometimes up to 30,000 tons.

I understand that circumstances and law on the Thames do not allow tows longer than 400ft, and therefore the cargo load is very restricted. In my opinion, this load capacity can be increased by at least 30 per cent when the tug pushes the barges. This method gives many advantages. The barges can be built fuller and shaped for pushing ; also, they can be arranged tightly together, which, as the author states, the lightermen prefer. Further, the sides of the barges do not need to be inclined. The propulsive conditions of the tug can be better, especially when the propeller tunnel is extended further forward and the propeller is raised so that the blade tips are about 30 per cent of its diameter above the water line. If this type of propulsion is adopted in the Thames tug it may reduce the draught considerably.

Dr. G. Hughes : The author says the main purpose of his company's carrying out full-scale tests is to improve efficiency, and I ask whether he would say whether pushing rather than pulling has been considered by the company. Reference was made by Mr. Davies to maximum integration. I think the point is that, if you are pushing, obviously there is maximum integration ; in other words, there is no space between the barges.

Professor E. V. Telfer : I thought our Teddington colleagues would have enlightened Mr. Griffith on something of the history of Thames barge tests. When the Thames barge form was tested for resistance, probably as far back as 1927, the late Dr. Baker presented a paper and showed that he was able to improve the resistance of the standard Thames barge by no less than 27 per cent. But the improved form was quite unacceptable to the Thames barge owners because, whilst a barge must be such that it will tow easily, it was also a fundamental that it could be stopped easily ; individual barges had to be slipped off a tow, and the men should be able to stop them in time to

give them their ultimate position near the river bank. Because of its very bad stopping qualities, the improved form of barge was not adopted. I wonder if Mr. Griffith will say how nearly the model predicted what the ship did. From his diagram it is quite impossible to say whether the model results are within 10, 20 or 50 per cent of those of the ship, and we should at least know how far the model is going to tell us what is going to happen to the ship.

The meeting was resumed on the morning of Wednesday, July 10, in the Large Lecture Theatre of the University Engineering Laboratories, with Mr. J. H. B. Chapman in the chair and with the reading of :—

DESIGN OF WOODEN NAVAL VESSELS

By K. G. Evans, R.C.N.C.

Synopsis

The construction of modern wooden vessels over 100ft in length is discussed and illustrated by drawings and photographs of ships now building. These depart significantly from pre-second world war types, largely due to the extensive use of laminated timber for keels, stems and frames, the fabrication of which is described as well as designs of composite plywood mahogany structures. Methods of theoretical stress analysis are described and suggestions made for taking greater advantage of the strength of timber by the wider adoption of ring connectors. Miscellaneous problems arising from the use of timber, particularly protection against dry rot and marine borers, are discussed and a list of works of reference given.

Discussion

Mr. J. H. B. Chapman : This paper describes the structural arrangement of the 106ft survey vessel, but the method of construction applies generally to a number of types of ship. We believe the method is sound, even though it may be conservative as regards strength. The detail might seem elaborate, but the design was arrived at primarily to ensure good ventilation and air circulation to deter the onset of dry rot. There were many practical considerations arising in the train of the glueing techniques, and the Admiralty congratulate the small shipbuilders on the way in which they have accepted the challenge of the new methods and the training of the craftsmen required.

We have not had much operational experience with these craft because most of the ships have been put into reserve. Our two biggest problems are those of repairing the craft and of preserving them, whether they are operational or in reserve.

Our experience with wood-built craft is not extensive and not very reassuring. Therefore, we have taken the best advice available in this country and have drawn on the experience of the U.S.A. and other countries, not only as regards methods of construction but also on the means of storage.

Two plans are being followed, and in both the ships are preserved by drying out and a measure of cocooning. For vessels laid up afloat, salt-water berths have been chosen and the whole of the upper works covered by " Arks " to keep out rain and weather. Other vessels are being laid up ashore in ventilated sheds, which we hope will enable them to keep in the " as new " condition for many years.

Mr. C. W. Whipp : I should like to comment on the strength of hull planking. In the case of double-planked hulls it is worth paying attention to the ratio between the thicknesses of the inner and outer planks. Common sense might suggest making the planks of equal thickness so that all parts would bear an equal strain, but I think that common sense would mislead us. In the author's illustration of a typical framing section the outer plank is shown as $\frac{7}{16}$in and the inner as $\frac{1}{2}$in, making a ratio of 0·57. From the point of view of strength it is possible that an even smaller thickness ratio could be worked with advantage, and there is some experimental confirmation for this. There are some practical lower limitations to the value of the ratio. For instance, if the thinner plank is made too thin it will tend to split in way of the fastenings. One thickness of wood is, on a strength/weight basis, the most economical arrangement of all, but it loses the advantages of the double skin, such as the better watertightness.

Mr. W. J. Holt : Within the last ten years the boat-builder has received a gift from the research chemist of a glue which is waterproof and is curable within the conditions obtaining in the average glue shop. Mr. Evans does less than justice to traditional methods of wooden ship and boat building and to existing Classification Society rules. He may not appreciate the difficulties involved in achieving a joint between two pieces of wood which approaches the breaking strength of the wood. It is worth while to note that Classification rules have produced numbers of first-class racing yachts which have owed little to glueing or lamination technique and are as light as you could wish. In design we must take account of the function of a boat, and it seems to me that a fishing boat and a speed boat can exist quite happily together, each being completely functional.

The paper gives little indication of the price to be paid for indulging in a high degree of lamination of structure. The technique involves a maximum of sawmill work on the timber, careful seasoning and control of the moisture content of the timber after seasoning ; it involves the use of expensive glues and, for large laminated members, considerable outlay for plant, and the employment of a big labour force.

If I have to design an inshore fishing-boat I can probably pick up grown oak crooks for frames which will do the job and can produce a boat at an economic cost, whereas if I go in for lamination the boat is probably too expensive. On the other hand, if I have to design a speed-boat, the necessity for longitudinal strength and maximum weight economy with the refined hull will encourage the use of glue and lamination.

It has been my experience that the more you glue a boat the stiffer you make the structure, whereas the great advantage of wood construction having some degree of flexibility is that the structures absorb punishment without giving way altogether.

Mr. Evans has referred to the timber stringer frame construction as having originated in the " E " boats. The structure described, however, was used in the Admiralty designed 72ft H.D.M.L.s which saw service in World War II, and in the C.M.B.s of World War I, and also in a design developed in the early 1900s, which made use of this method of construction.

Mr. Selman : I am surprised that Mr. Evans has not referred to the gap-bridging ability of modern glue. The old glues crazed when they hardened, and in the lamination technique it is essential to take care of small gaps between the separate planks. The author also makes the technique appear involved by his reference to the need for roughening. I have never found that roughening is necessary in order to get a glued joint.

He illustrates a frame where, in place of the conventional connection by brackets between a beam and a frame, he curves his lamination round from one member to another. I think that what is needed is a positive strut between the two members, and that the positive member, when the frame is subjected to outside pressure, would depend not on the way the laminations are arranged, but on the bolts which reinforce them. Some years ago I tested a frame of this sort and found it was much weaker than a joint made by connecting a laminated beam and a laminated frame by two glued ply brackets.

I am sure that fasteners would not be so often necessary if boat-builders did not pin their faith to great bolts. In steel construction you equate the strength of the rivets against the tearing strength of the plate in between, whereas in boat-building you should use a large number of small fastenings and relate those to the crushing strength of the wood.

May I add a word of warning about plywood? It has enormous panel strength but it should be used with caution as tension or compression members. Ordinary three-ply has two pieces in one direction and the other across and you cannot treat it as a homogeneous tension member.

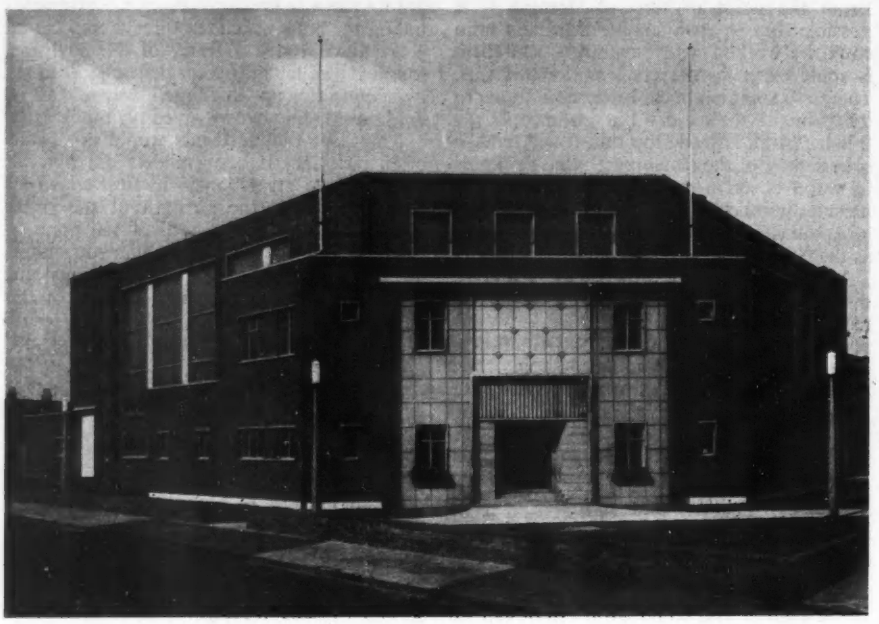
Mr. R. Baker : The typical framing section shows a modern all-round glued laminated frame, kept away from the shell by traditional solid timbers ; it shows the two skins secured to each other by thousands of miscellaneous fastenings, and these skins and the timbers again secured to the frames by thousands more. Mr. Evans may claim that, in spite of its novelty, " the scantlings are well on the conservative side." They need to be if every member, whether glued or not, is to be pierced for such a mass of nails, screws, bolts, &c. In the proposed design of a stiffened flat he illustrates a perfect scheme for the encouragement of dry rot.

In regard to fastenings, he starts off as if to eliminate at least some varieties of metal fastenings, and in his conclusions he almost, it seems, senses that glue and spikes do not go together but then at the last he throws in the connector. I could not find mention of oiled calico in the text, but the idea of a leak stopper, such as oiled calico, that should lubricate and so encourage sliding between the two skins seems to be absolutely contradictory to " the wider adoption of glued composite structure."

From the earliest times wood shipbuilding has suffered from the difficulty of fastening the wood and of stopping leaks, and Mr. Evans is quite right in saying that every fastening is a source of weakness ; but the consequences of this weakness are first and worst in the skin of the ship. If, therefore, logic is to be applied to this craft and new methods are to be used, surely it would have been more appropriate to have started the glueing between the skins and between the skin and the framework. Such a procedure, to use Mr. Evans's words, would have saved a lot of weight and have made the whole thing stronger. Perhaps the author would explain why his new techniques have been applied everywhere except where the greatest benefit is likely, and comment on the reason why, instead of reducing some of the metal fastenings, he actually proposes to use more.

Because of the timbers and stringers, the laminated frames are not in contact with the skin, and from the point of view of incipient rot this is probably a good thing. But it must be pointed out that this separation throws away, so far as the frame is concerned, the flange effect of the skin. The frame, therefore, is a curved beam loaded through the stringer and it should have been designed accordingly. The author's arrangement wastes wood to something like 80 per cent of the weight of each frame. It also wastes about the same proportion of glue ; and, if it is strong enough, it is all too stiff.

(*To be continued*)



Main Drainage in the City of Kingston upon Hull

No II—(*Continued from page* 88, *July* 19)

Humberside pumping station, which will serve the low-lying main drainage area of West Hull and Haltemprice, is due to be inaugurated to-day at a civic ceremony when Mr. Henry Brooke, the Minister of Housing and Local Government, will open the station. In Part I of this article we explained the general scheme of drainage in Hull, and gave details of the joint scheme in the western area. Here we give an account of the Humberside pumping station.

IT may be understood from the description we have already given that the cardinal element in the West Hull and Haltemprice joint scheme is the new pumping station, which is now in operation with the initial plant installation completed. Its design and layout are somewhat complex, but present unusual interest for both the civil and the mechanical and electrical engineer. For clarity, therefore, we have divided the subsequent description of the pumping station, giving first an outline of its layout, followed by some explanations of the design problems involved, then more detailed descriptions of the plant installed, including an account of the stepped-electrode pump control system, and finally some notes on the civil engineering problems of its construction. These latter topics will form Part III of the article. The principal statistics relating to the pumps and other plant installed, and the range of heads and flows involved, are listed in the accompanying table.

The inset drawing of the pumping station facing this page, shows plans at different levels and cross sections, from which the general layout and the flow of sewage through it can be followed. As may be observed, an " arrowhead " layout is utilised, with the main plant arranged in two identical sets on each side. Sewage flows in at the base of the " arrow " through two rectangular inlet culverts to a mixing chamber (which we illustrate) controlled by penstocks. It then passes through a preliminary treatment of screening and grit removal, the plant for which is laid out along four channels, each 11ft wide. It first passes through coarse screens, and then most of the sand and grit is removed. The grit channels are not the long, constant-velocity channels familiar in many sewage treatment plants, but are more in the nature of collecting sumps. The older sewers serving the old station were not constructed with self-cleaning velocities, and gritty solids are thus rolled or swept down these sewers to the pumping station and do not need " settling out." Grit is removed by chain-bucket elevators. There is then a set of fine screens, continuously raked, and the screenings are macerated.

The four sewage channels then divide, two of

Humberside Pumping Station

Levels and Flows.

(Levels given to Town Datum 20ft below Ordnance Datum (Newlyn))

Invert level of inlet culverts at mixing chamber of pumping station	−5·10 T.D.
Invert level of outfall sewer	+10·91 T.D.
Tidal levels in river at outfall chamber :	
H.W.O.S.T.	+32·00 T.D.
L.W.O.S.T.	+9·07 T.D.
Normal range of pumping heads	14ft to 45ft.
Normal range of design flows :	
Initial dry weather flow	2,000 c.f.m.
Ultimate dry weather flow	3,000 c.f.m.
Initial storm water peak	30,000 c.f.m.
Ultimate storm water peak	63,000 c.f.m.

Ultimate Installation of Pumping Plant.

Dry weather flow pumps	Four 30in vertical shaft mixed flow pumps.
Motive power for pumps	Four 345 b.h.p. synchronous induction motors.
Capacity of each pump at mean tide	3,000 c.f.m.
Storm water pumps	Eight 50in vertical shaft mixed flow pumps.
Motive power for pumps	Eight 975 b.h.p. synchronous induction motors ; two 1320 b.h.p. diesel engines.
Capacity of each pump at mean tide	9,000 c.f.m.

Each diesel engine also drives a standby 125kVA alternator for house services.

Initial Installation of Pumping Plant.

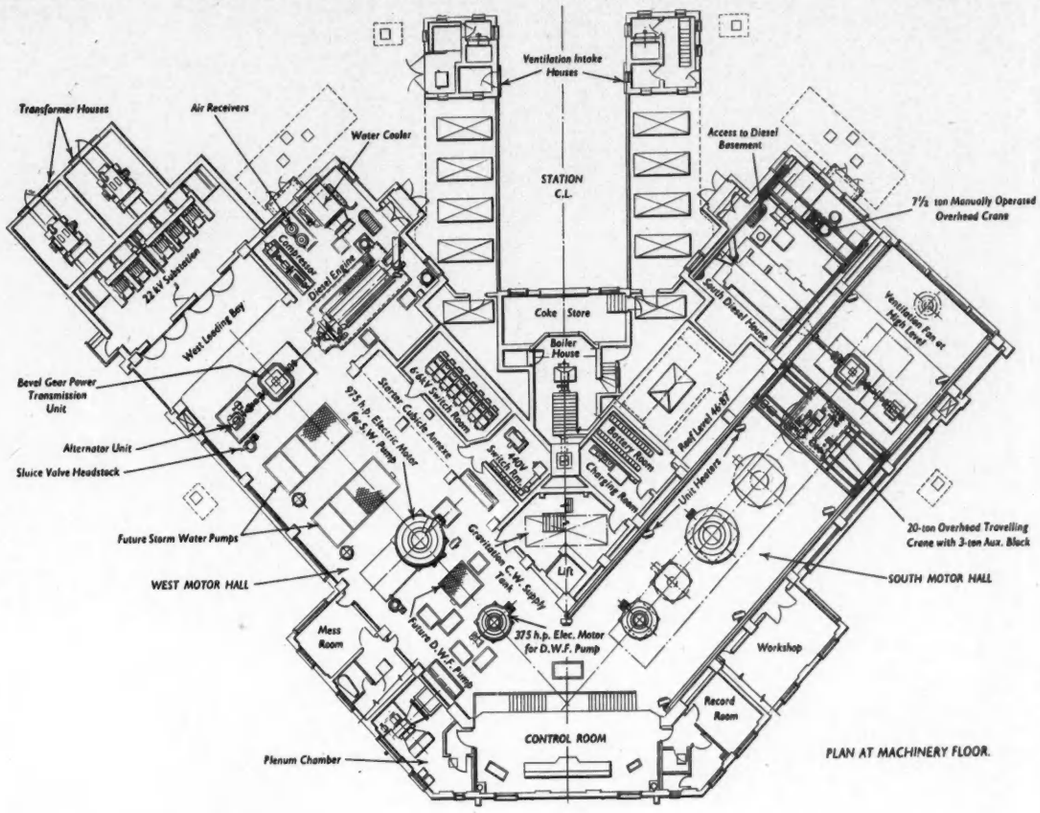
Dry weather flow pumps	Two 30in mixed flow pumps.
Storm water pumps	Four electrically driven 50in mixed flow pumps.

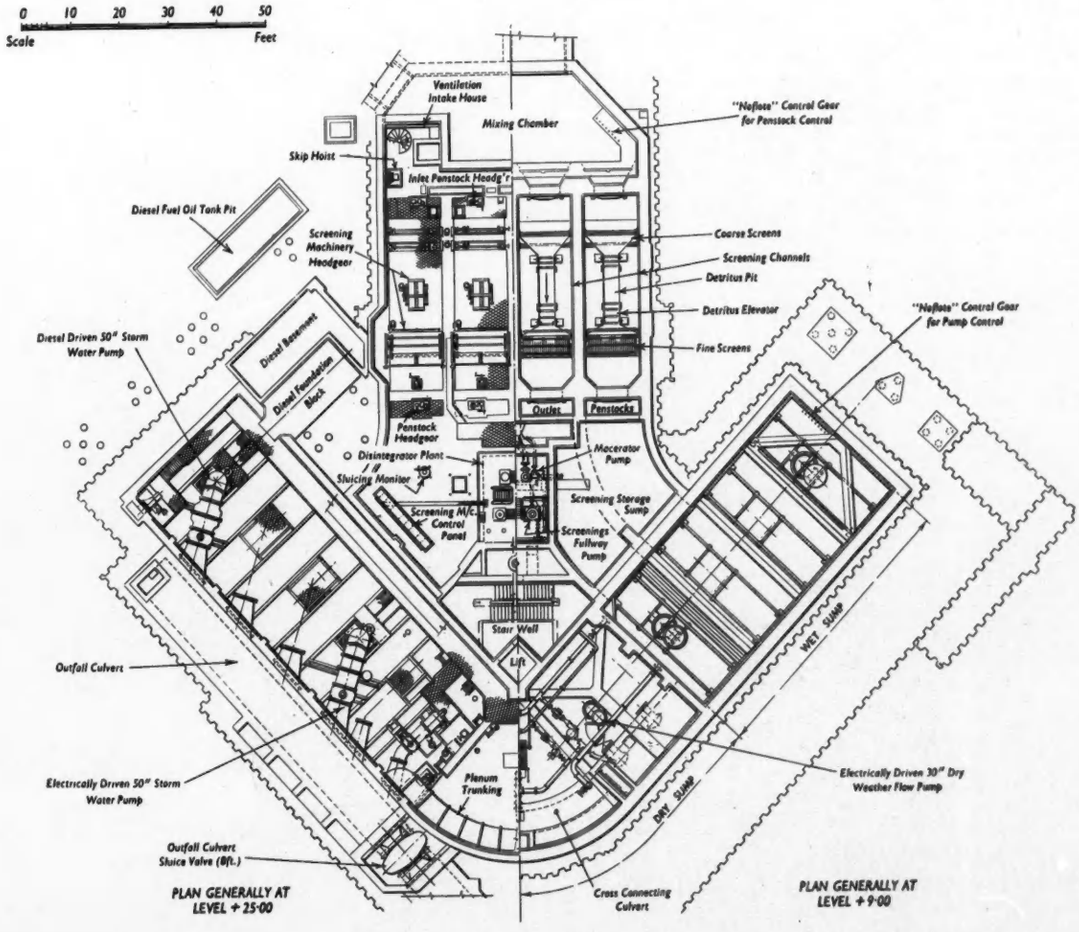
Screening and Maceration Plant.

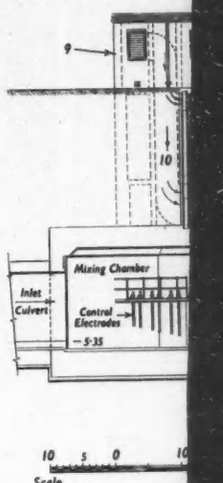
Four 10ft 8in wide by 10ft 2in duplex vertical-lift bar screens (4in spacing).
Four 24in chain bucket detritus elevators.
Four 10ft 8in wide by 12ft 6in continuously raked inclined bar screens (¾in spacing).
Two 10in i.d. by 8in o.d. medium grade vertical macerator units.
Two 6in unchokeable vertical screenings transfer pumps—capacity 110 cubic feet per minute.
The whole of the screening and macerating plant is electrically driven.

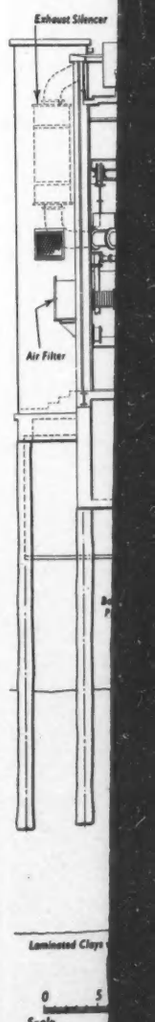
(Left) The mixing chamber measures 51ft by 21ft and is 15ft high. In the centre can be seen the 8ft by 9ft western inlet culvert, whilst the 11ft by 11ft northern inlet culvert is on the right. Inlets to three of the four screening channels can be seen on the left with an observation gallery above. (Right) The outfall bell-mouth manhole at the northern end of the 10ft 9in diameter outfall sewer. The entry shaft and safety chains can be seen, whilst in the background are the two 8ft wide by 9ft 6in deep discharge culverts of the pumping station. In the background, in the left-hand culvert can be seen the partly raised plug of one of the 96in diameter outfall sluice valves

HUMBERSIDE PU

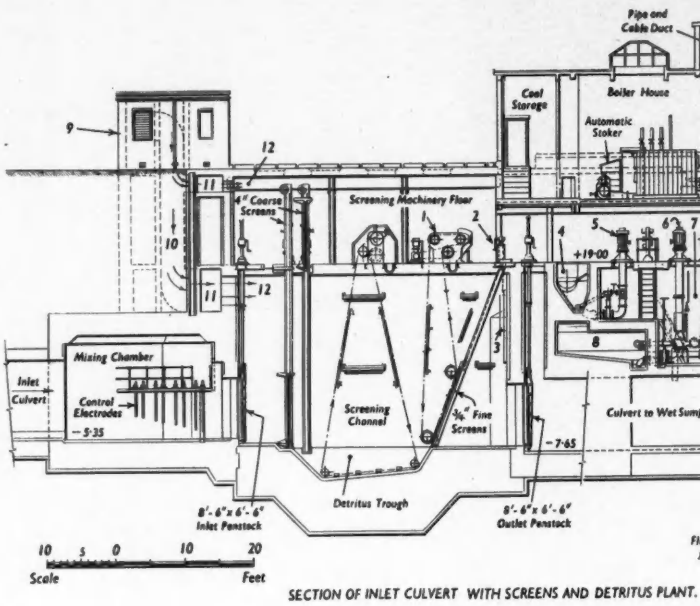




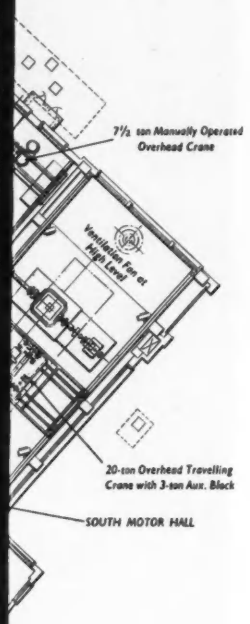




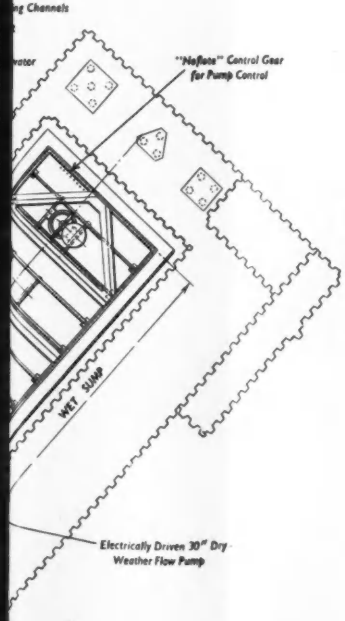
HUMBERSIDE PUMPING STATIO



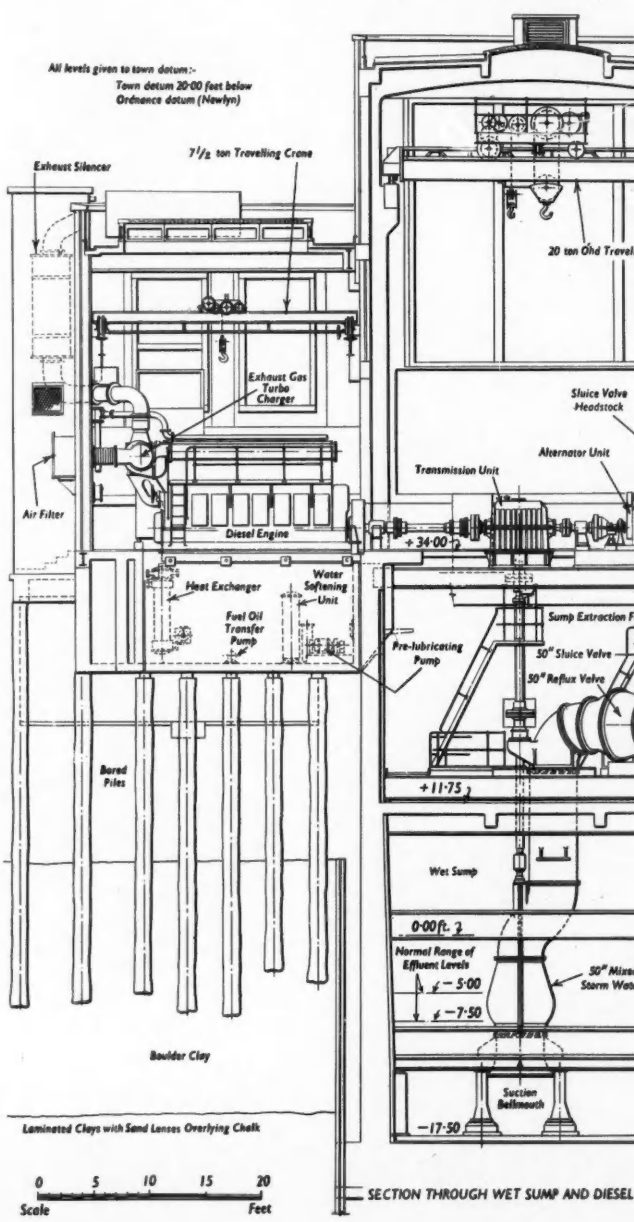
SECTION OF INLET CULVERT WITH SCREENS AND DETRITUS PLANT.


7½ ton Manually Operated Overhead Crane
Ventilation Fan at High Level
20-ton Overhead Travelling Crane with 3-ton Aux. Block
SOUTH MOTOR HALL

PLAN AT MACHINERY FLOOR.

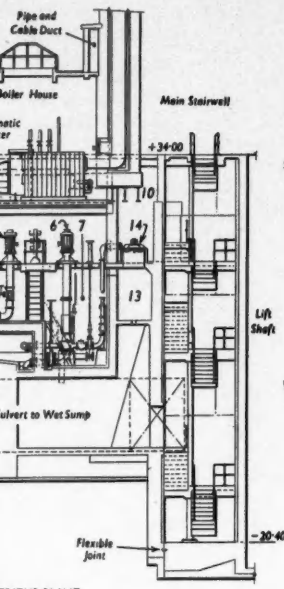


PLAN GENERALLY AT LEVEL +9·00



SECTION THROUGH WET SUMP AND DIESEL

TION



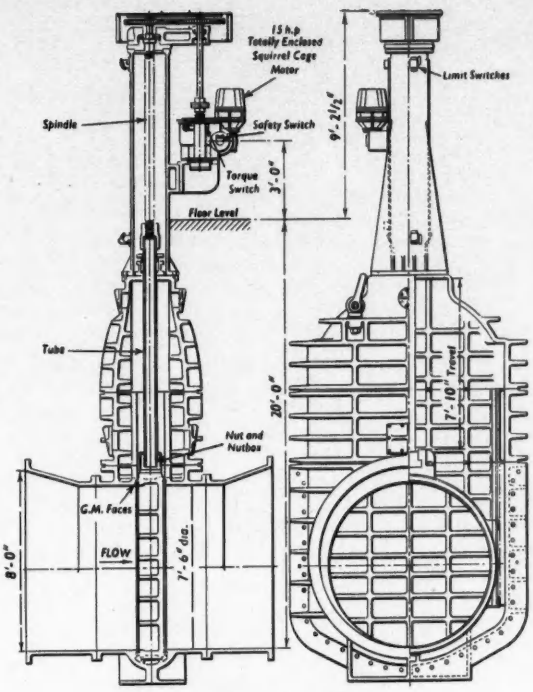
SCREENINGS PLANT.

1. Fine screen mechanism.
2. Fine screen hoisting gear.
3. Counterweight.
4. Screenings trough.
5. Disintegrator pump.
6. Transfer pump.
7. Disintegrator chamber.
8. Macerated screenings storage sump.

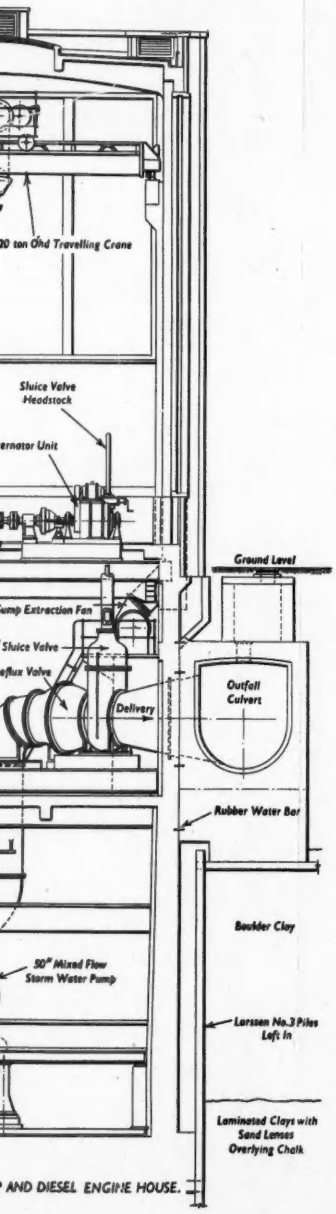
VENTILATION.

9. Ventilation intake house.
10. Air shaft.
11. Air duct.
12. Air register.
13. Extraction chamber.
14. Extraction fan.

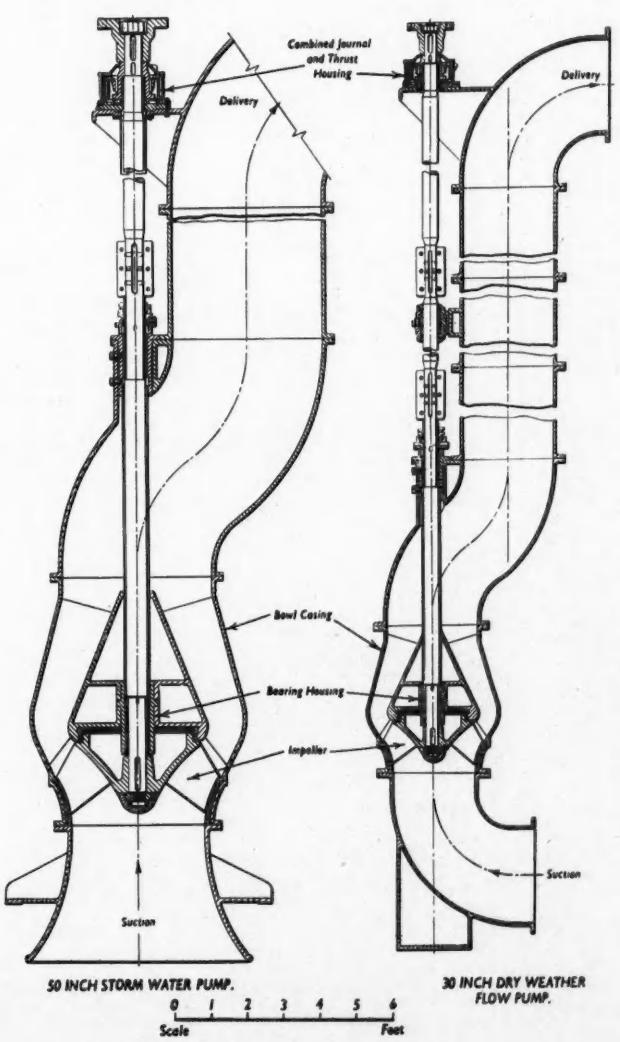
TRITUS PLANT.



7'-6" DIAMETER OUTFALL SLUICE VALVE.



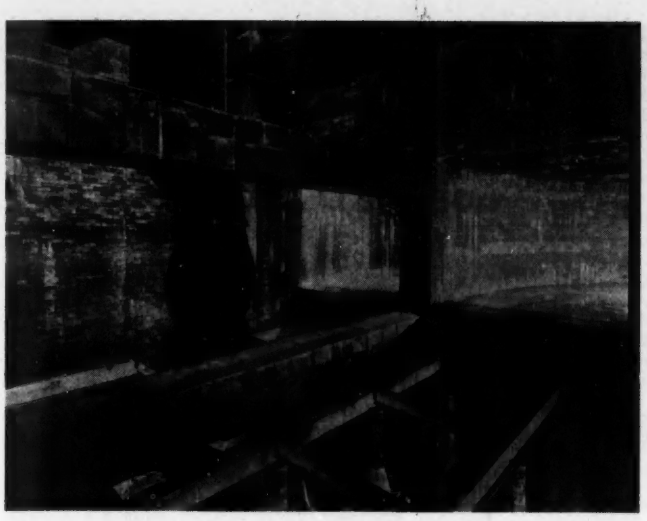
P AND DIESEL ENGINE HOUSE.

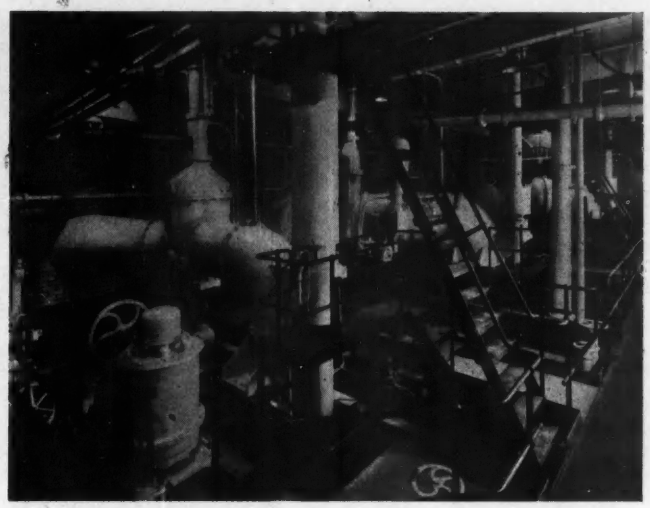


50 INCH STORM WATER PUMP.

30 INCH DRY WEATHER FLOW PUMP.

Scale 0 1 2 3 4 5 6 Feet





(Left) Part of a wet sump. The two inlet flumes may be seen on the right, and one of the 50in storm water pumps and steelwork for the next pump are seen in position. Under d.w.f. conditions the sewage level in the sump will be about one-third of the way up the inlet flumes, and the pump impeller will be completely submerged. (Right) The pumping station at pump discharge floor level. One of the 30in pumps is visible in the foreground, with the 50in machines behind

them passing to the wet sump in the left-hand branch of the arrowhead shape, and two to the right. Storm water pumps are installed in each of these wet sumps, but the dry weather flow pumps are in a dry sump in the centre, between them. A culvert connects the two wet sumps together and provides an inlet channel for the dry weather flow pumps, as shown on the lower plan facing page 116.

There is a tank, for storing the detritus and macerated screenings, situated above the four main culverts, at the point where they branch into the wet sumps (also shown on the same plan). The screenings liquid can be pumped from this tank, through an 8in rising main, independent of the main outfall sewer, to the river or can be drained back into the wet sumps. Normally the screenings liquid is discharged to the river only on the ebb tide.

The pump discharge culverts run along the outside edge of each of the wet sumps, and join in front of the station, from where an outfall sewer 10ft 9in in diameter passes to the river outfall, 981ft away. The outfall sewer is illustrated opposite.

The main facilities at ground level include two motor halls to accommodate the main pump motors and the two standby diesel-driven alternators, two loading bays, two diesel houses, two battery and battery charger rooms, two 440V switch rooms, two 6·6kV switch rooms, two transformer houses, a 22kV substation, stairwell, lift shaft, a coke store, boiler house and chimney and an administration block containing the main control room, which overlooks the two motor halls.

Each leg of the main motor halls has a 20-ton electric gantry crane (with 3-ton auxiliary hooks) capable of lifting out the heaviest storm water pump component, and of carrying it to the loading bay. The height of the motor halls is such that a 50in diameter storm water pump assembly may be lifted out of the wet sump of the substructure and carried to the loading bay without fouling the electric motors. The diesel engine houses each have a 7½-ton hand-operated gantry crane. In addition to glass block fenestration, large areas of the internal walls and roofs of the motor halls and diesel engine houses will be covered with acoustic tiling to reduce noise transmission within the building.

The appearance of some of the principal plant installed in the station, and of one of the machine rooms, can be seen from the various photographs which we reproduce.

Pump Design and Construction

The principal mechanical engineering problem which presented itself in designing the pumping station was the selection of a pumping plant which was capable of dealing economically with the very wide variations in eventual capacity. The plant also had to deal, as an interim measure, with the more restricted range of capacities of the scheme as it would exist at the time of commissioning, whilst preserving reasonably high efficiencies and without imposing extra heavy starting loads on the supply system or the prime movers. The flow figures illustrating this point are given in the table. The range of spare parts to be carried was also considered at this stage. Approximately 98 per cent of the total quantity pumped per annum will be dealt with by the dry weather flow pumps, which in consequence will sustain the greatest wear. The design was, therefore, based on two sizes of pumps only, namely, 30in dry weather flow pumps with a mean capacity of 3000 cubic feet per minute and 50in storm water pumps with a mean capacity of 9000 cubic feet per minute.

The first section of the scheme involved the installation of four storm water pumps and two dry weather flow pumps, giving a total mean capacity of 42,000 cubic feet per minute, which is reduced to approximately 30,000 cubic feet per minute under the worst possible combination of storm and tide. Experience at East Hull, where the storm water pumps have a capacity four times that of the dry weather flow pumps, indicated that this range was a little too high, and that a capacity ratio of 3 : 1 was probably the optimum, from the operational point of view.

A further important design decision was to fit the storm water pumps in wet sumps as opposed to the dry sump system, which had always previously been used in Hull. Wet sump installations could not be commended on the grounds of accessibility or ease of maintenance, but to construct a dry sump of the requisite size with a wet sump of adequate capacity next to it would have involved very heavy additional costs in any case, and was precluded by the fact that no suitable site could be found. The decision to place the storm water pumps in wet sumps was to some degree justified by the fact that all these machines together would not, on average, operate for more than 220 hours in any year, and hence it is unlikely that it will be necessary to open them up more regularly than once per annum.

Because of the satisfactory service given by the vertical single-inlet-bowl screw pumps in East Hull, the same equipment for both dry weather and storm units was selected for the new station. The vertical spindle storm water pumps are among the most powerful of their kind ever to be manufactured in this country and are suspended 30ft down in the wet sump from a substantial steel grillage. The sectional arrangement of one of these pumps is shown in the inset drawing. They are mixed flow machines, each with a cast iron bowl casing made in two halves. The single-entry, gunmetal impeller is keyed to a high tensile steel shaft and is secured by a gunmetal domed nut. The casing and impeller have renewable gunmetal and phosphor bronze wearing rings at the points of running clearance. A cast iron off-set bend on the discharge side of the pump casing enables the vertical shafting to be outside the rising main. Within the casing and off-set bend the shaft is protected by a steel tube through which grease is fed under pressure to the gunmetal pump bearing bush. A rotary gland is fitted where the shaft emerges from the off-set bend. The shaft is provided with renewable hard phosphor bronze sleeves through the bearings.

The rising main and delivery bend are of cast iron, and a combined thrust and journal bearing is mounted on a bracket integral with the discharge bend, this bearing being designed to take the weight of the rotating parts, together with out-of-balance hydraulic thrust. The delivery bend also has feet cast integrally for mounting the whole machine on the steel grillage.

The electric motors are supported on an independent steel grillage 21ft above the pump discharge level. Similarly the bevel gearboxes for the engine-driven pumps are also mounted at this level.

The dry weather flow pumps are generally of similar construction to the storm water pumps, but are installed in a dry sump, a cast iron suction bend with piping serving each of them.

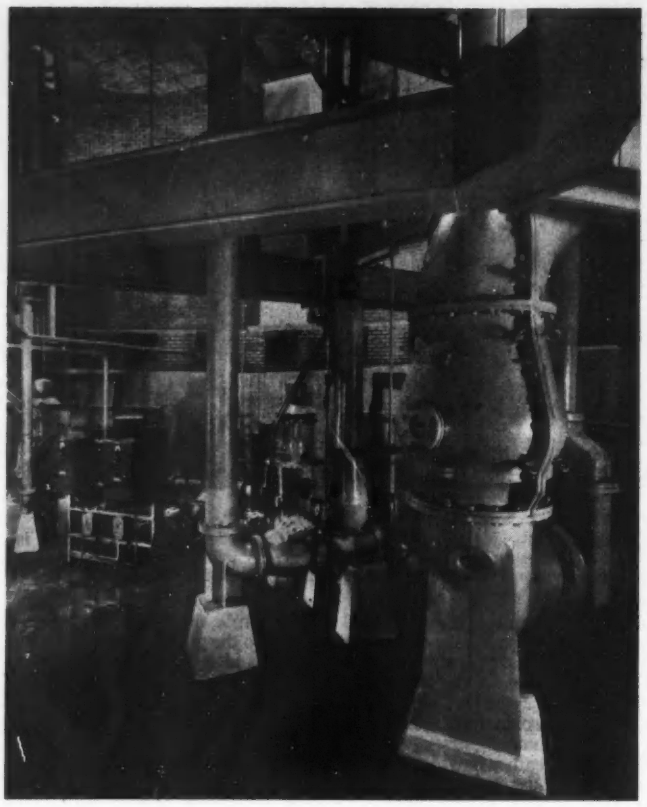
The electrically-driven storm water pumps are provided with 50in self-closing butterfly valves, together with 50in bore electrically-operated discharge sluice valves for isolation. The standby diesel-engine-driven storm water pumps sets also have electrically-operated sluice valves, but the reflux valve in this case is of the multi-flap type. The dry weather flow pumps have electrically-operated suction sluice valves and self-closing discharge sluice valves.

Each of the storm water pumps is rated to deliver 56,000 g.p.m. against a head of 45·5ft when operating at 300 r.p.m. Corresponding figures for the dry weather flow pumps are 18,700 g.p.m. at 46ft and 500 r.p.m. All pumps were designed for optimum efficiency at a total head of 40ft, which is the approximate mean head throughout the full range of tides and throughputs, and the estimated efficiencies at this rating are as follows :

	Hydraulic efficiency, per cent	Hydraulic and electric efficiency, per cent
Storm water pumps	88 ...	82·7
Dry weather flow pumps	84 ...	79

As in the case of the East Hull installation a high overall efficiency, although desirable in view of the heavy power consumption, is possibly less important than the preservation of a flat characteristic power curve throughout the range of heads. The shaft horsepower absorbed by the pump does not vary more than 5 per cent on either side of the mean in the case of the dry weather pumps and 2 per cent in the case of the storm pumps, thus keeping the maximum demand on the supply network as low as possible.

For all practical purposes the two halves of the station may be considered independent ; they have independent sources of supply with interconnection at both 6·6kV and 440V and independent sump and discharge culvert arrangements so as to enable either sump and discharge



(Left) Part of the dry sump with a 30in dry weather flow pump in the foreground, and auxiliary pumps in the background. (Right) The west motor hall viewed in a southerly direction. In the foreground the right angle bevel drive gear serving No. 1 storm pump is seen with a standby alternator coupled to it. Two motors for main storm and dry weather flow pumps can be seen in the background with the control room at the head of the staircase

culvert to be serviced whilst the other is kept in use. The dry weather flow pumps are, however, contained in a single pump chamber but do in fact draw from the independent wet sumps, and to this extent are also independent of one another.

The ultimate installation of plant will comprise six electrically-operated storm water pumps and two diesel-operated storm water pumps, together with four electrically-operated dry weather flow pumps, the diesel-operated sets being primarily for use in the event of mains failure. The normal throughput of the station does not exceed the capacity of these two diesel storm water pumps, operating together, for more than eighty hours in any normal year. For serious trouble to develop within the drainage area it must, therefore, follow that a total failure of all electricity supplies must coincide with one of the peak periods, and since these peaks are usually of short duration (two to three hours) spread reasonably uniformly through the year, a higher scale of reserve equipment could not be justified on economic grounds. The diesel-driven pumps will, however, be brought into use when peak loads of the electricity supply system and of the pumping station coincide ; thus the " maximum demand " charges which have to be faced with an installation of this kind can be reduced.

Electrical Plant

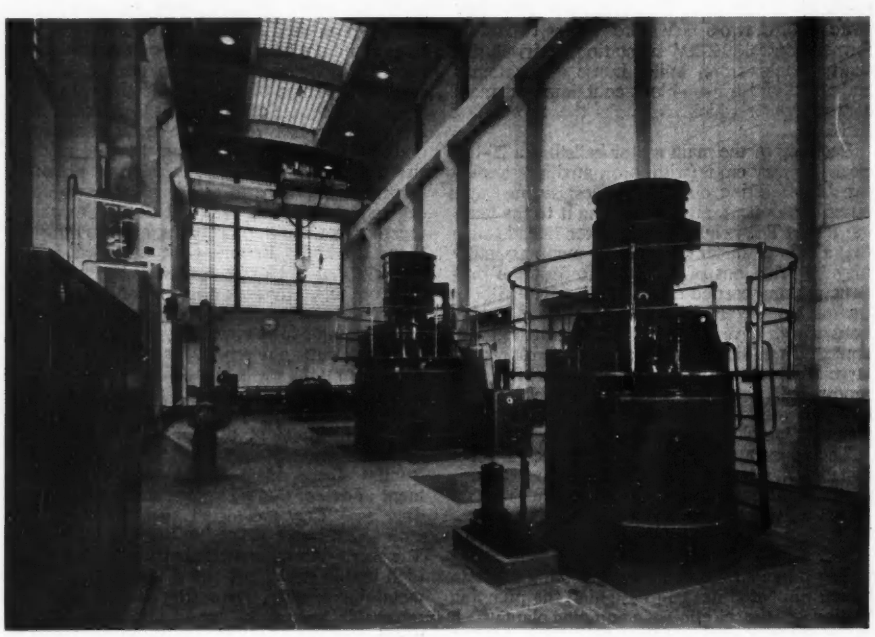
Synchronous induction motors are used for the electrically-powered pumps, rated at 975 b.h.p. and 345 b.h.p. for the storm water and dry weather flow pumps respectively, and operating at 300 and 500 r.p.m. respectively. The units do not differ radically in design from those installed at East Hull, but the flux densities in the magnetic systems have been kept down so as to reduce as far as possible the incidence of magnetic hum. The provisional design efficiencies of the machines so far delivered were 93·5 and 90 per cent respectively, and these efficiencies have, in fact, been slightly exceeded in works tests.

Diesel Engines

Two of the storm water pumps will be driven by turbo-charged oil engines having a twelve-hour rating of 1320 b.h.p. when operating under normal conditions of temperature and pressure at a speed of 375 r.p.m. This capacity is adequate to sustain the full hydraulic load of one storm water pump, including gearbox losses, and the full load of the 125kVA alternator, which is mounted in tandem with the gearbox and which will provide energy at 440V, three-phase, 50 c/s for house services in the event of a mains failure. The engines carry an overall margin of 20 per cent over the maximum anticipated load.

The drive is transmitted between the horizontal engine shaft and the vertical pump shaft by a totally enclosed right-angle bevel gear with continuous forced lubrication, the bevel gear on the vertical shaft being straddle mounted. The gear carries a substantial margin of power to allow for the inherent running irregularities of the engine and starting and shock loads which may be experienced during the pump's normal duties. Relative movement between the diesel engine and the gear is possible, so the drive to the gear has been arranged through a cardan shaft designed to preserve satisfactory drive under varying conditions of misalignment up to ½in in any direction.

Particular attention has been given to the silencing of the engines themselves, and silencers



Part of the west motor hall. One of the 345 h.p. dry weather flow pump motors can be seen in the right foreground with its control panel to the left. There is a storm water pump motor behind, and in the background the bevel gear of the diesel driven pump. The diesel engine house lies to the right

of extra large capacity accommodated in vertical chimneys will be installed. The cooling is on a closed circuit system, the engine jackets being served by softened water circulating through a heat exchanger and the primary water being passed through a forced draught cooler.

The diesel engines have the usual complement of mountings and are fitted for air starting. Air storage and air compressing plant is on an usually generous scale so as to reduce the time for recharging in the event of pressure being lost accidentally. No method is provided for disconnecting the engine from the pump whilst running up, and for this reason also adequate provision of compressed starting air is essential.

Main Electricity and House Services

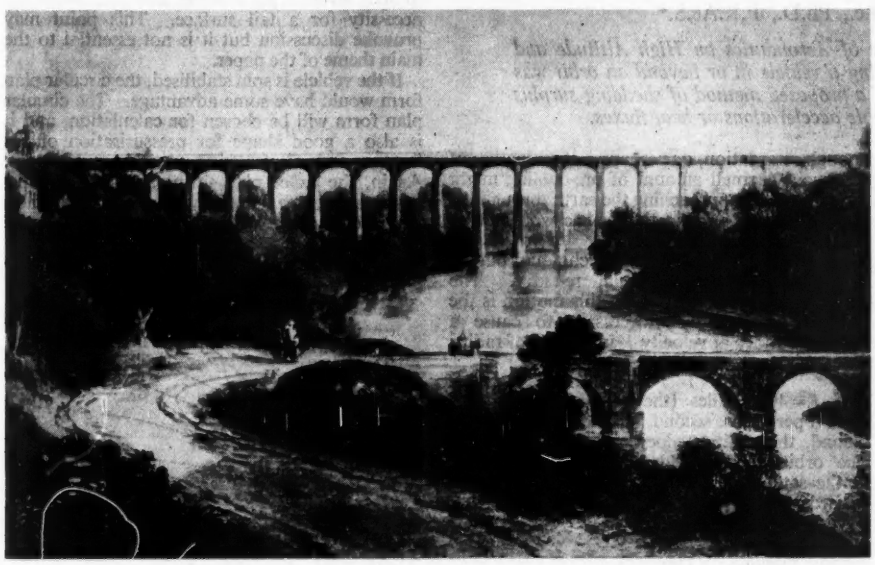
The new main 22kV substation is within the confines of the pumping station and is eventually intended to provide three supplies. Energy will be taken in bulk through duplicate feeders to two 3000kVA, 22/6·6kV transformers adjacent to the substation. The 6·6kV side of this substation is arranged in the form of a closed ring passing through two eight-panel 6·6kV oil circuit breaker banks arranged to serve the six main machines eventually to be installed in each half of the station, the two house service tranformers and the incoming and bus connecting mains. Interconnection is provided at both 6·6kV and 440V and, in addition, interlocked 440V services are available from the two 125kVA house service alternators which generate standby power in emergencies. These alternators cannot, by the nature of the hydraulic load, be synchronised in parallel or run in parallel with the public supply, and Castell interlocking is provided to ensure that this does not occur.

House services are on a comprehensive scale and include conventional medium-voltage lighting and power installations, plenum ventilating plant in the control room and the lower dry sump, low-pressure accelerated hot water heating for the main body of the building, a general service lift, fire-prevention services, and a central electrical clock installation. Two 20-ton electrically-operated motor cranes and two 7½-ton hand-operated cranes will be installed in the motor halls and in the diesel hails respectively.

Description of the pumping station continues in next week's instalment, and we have held over mention of the names of the various firms responsible for the work described here until the end of the article.

(To be continued)

Telford Bicentenary Exhibition



Thomas Telford was born on August 9, 1757. In honour of the bicentenary of this event, the Institution of Civil Engineers has organised a Telford Exhibition, which was opened on Monday morning by Lord Mills, Minister of Power. The exhibition has been arranged by Mr. Richard Buckle at the Institution's building, Great George Street, Westminster ; it will continue until August 10.

TWENTY-THREE years ago, the Institution of Civil Engineers held an exhibition in honour of Thomas Telford, F.R.S., its first president. That exhibition commemorated Telford's death a hundred years previously. Now, the Institution is commemorating his birth, 200 years ago on August 9 in an Eskdale shepherd's cottage. The records dealing with the seventy-seven years of Telford's life have again been studied, and the resulting exhibition emphasises, by the use of pictures, models, original letters and personal relics, how much of practical value the first president of the "Civils" contributed to this and other countries. Sir Arthur Whitaker, who is this year's president of the Institution of Civil Engineers, has appropriately said that "there are many engineers whose names have remained more familiar than that of Thomas Telford, though few of their works are so well known as his Menai Bridge, or his great canal crossing the Dee at Pont-y-Cysylte in its iron trough 127ft above the valley. It is often forgotten that during his lifetime, apart from a network of canals, many of which are still in use, he built more than 1000 bridges and many hundreds of miles of road, and but for the opposition of railway interests he would have built a splendid highway, such as in those days only he could have constructed, direct from London to Edinburgh."

The present exhibition tells the story of Telford's life and work. One wall of the exhibition hall carries a group of oil paintings of Telford, his collaborators and his work ; a photograph of one of these paintings, depicting the Pont-y-Cysylte aqueduct over the Dee valley at Llangollen, is reproduced above. On the opposite wall is a picture, painted specially for the exhibition by Mr. Leonard Rosoman ; it is a romantic landscape incorporating a number of Telford's works. There is also a statue of Telford, which has been completed by Miss Astrid Zydower. The many documents included in the exhibition are just as fascinating as the pictures. Some of them recall, for example, that the first president of the "Civils" was a poet with a deep interest in the history of his own country. In a collection entitled *The Poetical Museum*, which was published in 1784, Telford's poem "Eskdale" is included. A facsimile of the first page of the poem has a place in the exhibition ; at the head of the page it is stated that "Thomas Telford was bred a mason at the village of Langholm, on the Banks of the Esk ; a young man of no education, but common reading, assisted by some few books lent him by the neighbouring gentlemen."

After completing his apprenticeship as a mason, Telford obtained work in Edinburgh, where the New Town was being built north of Princes Street. Subsequently he wrote : "In the year 1782, after having acquired the rudiments of my profession, I considered that my native country afforded few opportunities of exercising it to any extent, and therefore judged it advisable (like many of my countrymen) to proceed southward. . . . I made my way direct to London as the great mart for talents and ingenuity ; and I was fortunate in getting employed at the quadrangle of Somerset-place buildings, where I acquired much practical information, both in the useful and ornamental branches of architecture."

Telford was summoned to Shrewsbury in 1787 by Sir William Pulteney, M.P., and his first task there was the rebuilding of Shrewsbury Castle, after which he was appointed surveyor of public works for Shropshire. As an architect he built Bridgnorth Church and excavated Roman Uriconium ; but, again as the exhibition stresses, his most significant works at this time were canals and bridges. Telford saw great possibilities in cast iron ; he was the first engineer to use it extensively for bridges and aqueducts and to make systematic experiments. Abraham Darby had made the first iron bridge, at Coalbrookdale, in 1779, and Telford's first (1795–96) was across the Severn at Buildwas. He designed a standard iron bridge for use in Shropshire. Of the later iron bridges designed by Telford, however, that at Tewkesbury (1823) was the most elaborate. An engraving included in the exhibition, taken from *Atlas to the Life of Thomas Telford*, shows that a "peculiar feature of the bridge is the masonry of the abutment wings, which, after being carried up solid three feet above the springing plates, is then composed of tall, narrow Gothic arches, which not only give the whole bridge a light appearance, corresponding with that of the iron arch (174 ft span), but also afford an enlarged passage to the high river-floods, which sometimes occur, and might otherwise seem to endanger the bridge."

In Shropshire, Telford built the Shrewsbury Canal, linking Ketley ironworks with the town, and at Longdon upon Tern he built the first iron aqueduct. On his Ellesmere Canal, joining the Mersey, the Dee and the Severn, Telford erected two famous aqueducts, one at Chirk, which carried the canal over the Ceriog valley, and the Pont-y-Cysylte, over the Dee valley, at Llangollen. This latter was actually a cast iron trough 1000ft in length. The Welsh were amazed to see canal barges being towed 127ft above the river, and Sir Walter Scott referred to Pont-y-Cysylte as the most impressive work of art he had ever seen. In the exhibition there is a model, believed to be the original model used by Telford, of a span of the Pont-y-Cysylte aqueduct. The picture of the aqueduct, which is illustrated above, was painted for Telford in 1826 by George Arnold, A.R.A. The aqueduct was built between 1795 and 1803. Telford's own description of the work says : "I had about that time carried the Shrewsbury Canal by a cast iron trough at about 16 ft above the level of the ground ; and finding this practicable, it occurred to me, as there was hard sandstone adjacent to Pont-y-Cysylte, that no very serious difficulty could occur in building a number of square pillars, of sufficient dimensions to support a cast iron trough, with ribs under it for the canal. I proceeded with confidence of ultimate success, although the undertaking was unprecedented, and generally considered hazardous. The height of the piers above the low water in the river is 121 ft, their section at the level of high water in the river is 20 ft by 12 ft, at the top 13 ft by 7 ft 6 in. To 70 ft elevation from the base they are solid,

but the upper 50 ft is built hollow, the outer walls being only 2 ft in thickness, with one cross inner wall ; this not only places the centre of gravity lower in the pier, and saves masonry, but insures good workmanship, as every side of each stone is exposed. I have ever since that time caused every tall pier under my direction to be thus built. The width of the waterway is 11 ft 10 in, of which the towing-path covers 4 ft 8 in, leaving 7 ft 2 in for the boat ; but as the towing-path stands upon iron pillars, under which the water fluctuates and recedes freely, the boat passes with ease."

Reference has been made here to but a few of Telford's works. There were many more which are now effectively recalled in the bicentenary exhibition ; projects such as the Menai suspension bridge of 1826, and work on the Holyhead road, harbour works at Dundee and Aberdeen, the building of the Caledonian Canal, and of St. Katharine's dock at Wapping. Telford's work abroad is also given prominence in the exhibition. In 1808 he received a formal request from the King of Sweden to assist in the construction of a ship canal between the North Sea and the Baltic. Telford made his surveys in the short space of seven weeks and submitted his proposals for building the Göta Canal. The work took twenty-three years, during which time there was a regular flow to Sweden " not only of British engineers, but of machinery, cement and other equipment."

Finally, the exhibits related to Telford's presidency of the Institution of Civil Engineers should not be overlooked. The Institution was founded in 1818, by Henry Robinson Palmer, as a society of young men anxious to promote civil engineering knowledge. About this time, Telford was withdrawing from professional engagements and bought his first house at 24, Abingdon Street, Westminster, where on Tuesdays he entertained engineers before taking them to Institution meetings. The early meetings of the Institution were held in coffee houses, but, shortly after accepting an invitation to become president, Telford secured, in March, 1820, premises at 15, Buckingham Street, which were the first to be occupied by the Institution. A copy of Telford's presidential address, delivered on March 21, 1821, can be seen at the exhibition. Many of his words are singularly appropriate now, as, for example : " In foreign countries similar establishments are instituted by Government, and their members and proceedings are under its control ; but here, a different course is being adopted, it becomes incumbent on each individual member to feel that the very existence and prosperity of the Institution depend in no small degree on his personal conduct and exertions."

Re-entry and Recovery

By W. F. HILTON, D.Sc., Ph.D., F.R.Ae.S.*

At last week's symposium at the College of Aeronautics on High Altitude and Satellite Rockets, the problem of recovering a vehicle in or beyond an orbit was attacked. We reproduce below details of a proposed method of shedding surplus energy without sustaining intolerable accelerations or heat fluxes.

AN aerodynamicist cannot assist in the design of vehicles to traverse the vacuum of outer space. At what altitude does aerodynamics again assume importance as we approach the earth's atmosphere ? The first effect of re-entry into the atmosphere will be the aerodynamic damping which will cause a gradual slowing down of the spin of the vehicle, which has been providing the vehicle with artificial " gravity " in space. This damping will act as a warning to the pilot to trim his vehicle and control surfaces to a flying attitude relative to the direction of motion of the centre of gravity. This will presumably be done by means of small rocket jets designed to produce and counteract pitching, yawing and rolling moments on the vehicle. Control surfaces would be of little use, as they would be too sluggish.

It is assumed that the vehicle will be aimed to one side of the earth, so as to pass tangentially through the earth's upper atmosphere. It must not be aimed at the earth's centre, so that it will descend vertically through the atmosphere. Although this vertical descent method would minimise the time spent in traversing the atmosphere, and hence minimise the heat input, it would also minimise the retardation of the vehicle by aerodynamic drag. (We might term this the Arizona Meteor style of re-entry.)

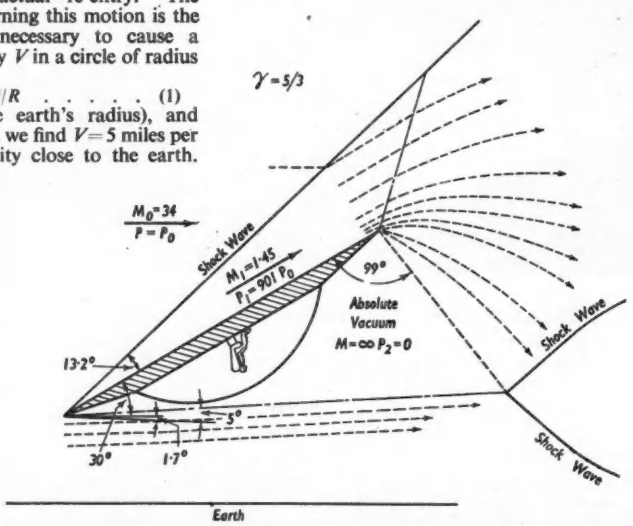
In aiming the vehicle at the edge of the earth, the pilot would select the side where the earth's rotation is carrying the atmosphere away from him. This would offer a possible decrease of relative speed of about 1000 m.p.h. (0·3 miles per second) or, say, $M=1\cdot3$.†

However, the velocity due to a free fall from an infinite height‡ is 7 miles per second, or $M=34$, and this selection of the point of aim does little to alleviate the unhappy lot of the crew, who will tend to have a choice between being fried if they pass too close to the earth or of disappearing on an open curve into the depths of space if they fly too far from the earth's atmosphere to achieve enough retardation, or perhaps a combination of the two. A small amount of pre-cooling might be achieved by approaching the earth through the earth's shadow, so that the vehicle would be as cold as possible.

So much for the approach technique, but let us now consider the actual re-entry. The important equation governing this motion is the familiar acceleration f necessary to cause a vehicle to move at velocity V in a circle of radius R.

$$f=V^2/R \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If $R=4000$ miles (the earth's radius), and $f=32$ft per square second, we find $V=5$ miles per second, the orbital velocity close to the earth. The orbit is preserved as the satellite is falling towards the earth with the gravitational acceleration of $g=32$ft per square second. Our vehicle, however, will have a velocity of 7 miles per second and this requires a steady acceleration of $2g$ towards the earth if it is to maintain height, and not to move away from the earth on an open curve, gaining height. As the earth will only provide g, aerodynamics must provide the rest. The amount of aerodynamic lift to be provided to maintain altitude at various speeds of flight varies as in Table I.



Suggested design of vehicle for re-entry into earth's atmosphere : heating effects confined to one side of vehicle

Aerodynamic Design of Vehicle

How should the vehicle be designed to give the crew at least a slender chance of survival ?

Now most aircraft are designed to produce the minimum aerodynamic drag, combined with an aerodynamic lift directed away from the earth, so as to sustain the weight. However, the present vehicle requires maximum drag on re-entry, although a small drag would have been desirable during the initial ascent through the earth's atmosphere. A sphere, then, would not satisfy this latter condition.

" Induced " drag due to lift is a drag which can be turned on and off at the pilot's will. Strange as it may seem, this lift force should be directed towards the earth, so as to prolong contact with the atmosphere, and to bend the trajectory round the earth as much as possible. Thus, the vehicle will fly upside down, by ordinary aircraft standards, at all speeds above 5 miles per second. At this speed it would execute a slow roll, so as to reverse the sign of the lift as in Table I.

Clearly, the sphere and the low drag, low lift (German " V.2 " rocket) type of vehicle must be avoided, and a high " induced " drag, high lift type employed instead. One immediately thinks of a very low aspect ratio wing, such as a square, circle or delta. Maximum lift is not sacrificed by using low aspect ratio, but it occurs at a much higher incidence and drag. This is correct for subsonic and low supersonic speeds. For the higher supersonic speeds, " induced " drag proportional to the square of the lift occurs at all aspect ratios. As the delta wing cannot generate a high lift if it is swept behind the Mach line at $M=34$, it will show no particular advantage over the other shapes. At these very high Mach numbers, the centre of pressure is very little ahead of the centre of area, and it might prove possible to spin stabilise the vehicle, and thus avoid the necessity for a tail surface. This point may provoke discussion but it is not essential to the main theme of the paper.

If the vehicle is spin stabilised, the circular plan form would have some advantage. The circular plan form will be chosen for calculation, and it is also a good shape for pressurisation of the human and electronic payload compartment. Again, the exact plan form may provoke discussion, but any shape having a low aspect ratio may be chosen, without affecting the broad discussion.

If we assume that the gas will be completely dissociated and ionised at the high gas temperature produced at $M=34$ (temperatures of the order of 5×10^4 deg. Cent.), then the value $\gamma=1\cdot66$ should be taken. The illustration has been prepared using this value. It will be seen that the value assumed for γ plays a minor part

TABLE I

Speed in miles per second	8	7	6	5	4	3	2	1	0
Lift/weight	−1·56	−1·0	−0·44	0	0·36	0·64	0·84	0·96	(1·0)
Mach number M=	38	34	29	24	19·2	14·4	9·6	4·8	0

* Chief Aerodynamicist, Sir W. G. Armstrong Whitworth Aircraft Company.

† The Mach numbers quoted in this paper are based on a speed of sound of 1100ft per second. It would be pedantically correct to avoid the use of Mach number, but familiarity is thought to outweigh any slight inaccuracies introduced.

‡ The velocity due to free fall from only 3·77 times the earth's radius is sufficient to produce a velocity of 6 miles per second. Thus, the considerations in this paper cover the re-entry problem, whether the flight is interplanetary or not.

in aerodynamic design of the vehicle, and will not affect the overall design very much, although it is a useful line of future research.

The hot surface of the vehicle has been kept as a simple flat plate, and is the main structural member of the vehicle. It will be expected to burn off to an appreciable extent.

The hot air flow on the pressure face will turn by means of a Prandtl-Meyer expansion and try to fill up the vacuum on the other (cold) side of the vehicle.

It will be seen that if the vehicle is flown in the manner indicated in the figure, the design criterion is to keep the vulnerable windows, door, radio mast, and so on, free from heat effects by making it impossible for the flow to turn the corner completely. The annulus surrounding the pressure bubble assists in keeping the heat off the canopy.

As the aerodynamic design of the hot surface presents a vacuum to the cold surface, there need be no aerodynamic design of this surface.

The spherical bubble canopy was in fact designed with an eye to the structural problems involved.

If, however, the vehicle has to be built on the earth's surface and rise through the atmosphere on its edge, a Mach number of 2·5 would be a likely vertical speed to compromise between rocket economy and tolerable temperature rise. This would give a maximum angle of canopy to base of 30 deg. if the shocks were to be attached.

In order to keep to higher altitudes, with lower pressures and hence lower rates of heat input, the wing loading must be small. The calculated values are shown in Table II, together with corresponding values for $\gamma=5/3$. Heat input per square foot is calculated as the product of drag in pounds per square foot times velocity in feet per second.

In the case of $\gamma=5/3$, the wing incidence is 30 deg. and the lift will be $\sqrt{3}$ times the drag.

Although the vehicle weight per square foot of surface may tend towards 100 lb per square foot, or even higher, it may be found possible to reduce this to 15 lb per square foot by very careful design. In any case, the re-entry height would appear to be 250,000ft ±20 per cent and this value will be used.

So far the vehicle has been treated as flying at constant altitude. It would take 26 deg. of latitude and 5 minutes' flying time to reduce speed from the re-entry speed of 7 miles per second to the satellite speed of 5 miles per second, if taken in one burst.

In practice the heat inputs in Table II look formidable for wing loadings above 5 lb per square foot, and the pilot would in fact break off contact with the atmosphere, after making certain that he had decelerated below 7 miles per second, the escape velocity.

He would then fly round the earth on an elliptical orbit and return some hours later for a fresh braking and heating flight.

He would ultimately circle the earth on a constant altitude satellite course at 5 miles per second.

From this point onwards the vehicle would be rolled into the more conventional attitude, with positive incidence, and an increasing proportion of the weight would have to be supported by aerodynamic lift, in accordance with Table I. This will be the severest phase of all, as it will be impossible to climb very high above the steady orbit, in the absence of power, in order to radiate heat into a vacuum, as at higher speeds.

It might be thought that the diminution in Mach number would alter the flow pattern appreciably, but this is not in fact the case. At $M=5$ the flow will only be able to expand round the corner through 32·9 deg. (instead of 5·0 deg. at $M=34$). It must be remembered that in the absence of radiation losses, the gas temperature will be restored to ambient when the flow regains ambient Mach number. This is due to the total temperature being unaffected by passage through a shock wave. (This statement must not be confused with surface temperature in the presence of a gas travelling at ambient Mach number. The surface will be very much hotter than the gas.)

There will thus be an altitude for steady flight at each speed, and these are tabulated in Table III for a vehicle having 100 lb per square foot wing loading, and neglecting change in g with altitude. This would cause the true height at 5 miles per second to be less than 1000 miles.

At 30 deg. angle of incidence the vehicle will be flying at a lift/drag ratio of $\sqrt{3}:1$, which is not the highest possible value. A lower incidence would give an improved L/D but result in burning the cool surface, and has therefore been avoided.

The importance of keeping down the wing loading to 10 lb per square foot instead of 100 lb per square foot will be apparent from Table III.

Table III also indicates the difficulty of returning from an interplanetary flight (as distinct from a lunar flight or one into empty space), as an extra mile or two per second will be acquired due to the sun's gravitational field. All of this extra velocity above 7 miles per second must be taken off in the first re-entry into the atmosphere, or else the vehicle will disappear on an open hyperbolic orbit.

TABLE II—*Steady Flight at 7 Miles per Second, $\gamma=7/5$*

Altitude in feet	Atmospheric pressure in lb/ft² (Ref. 2)	Wing loading in lb/ft²	Density Slug/ft³ (Ref. 2)	Heating in kilowatts per square foot	
				$\gamma=7/5$	$\gamma=5/3$
200,000	0·7887	605	$7\cdot246\times10^{-7}$	30,700	18,100
250,000	0·1453	112	$1\cdot852\times10^{-7}$	5,680	3,320
300,000	0·01976	15·1	$2\cdot258\times10^{-8}$	767	452
350,000	0·004129	3·2	$3\cdot664\times10^{-9}$	162	94·5
400,000	0·001212	0·9	$8\cdot620\times10^{-10}$	49	27·9
450,000	0·000437	0·3	$2\cdot68\times10^{-10}$	15	10
500,000	0·000181	0·1	$9\cdot75\times10^{-11}$	5	4·1

Mean free path of molecules has now become similar to vehicle dimensions. Theory no longer applies. Also note that "g" has decreased to 30·6ft/sec.² at 500,000 ft. This would affect more refined calculations.

TABLE III—*Steady Flight at Various Speeds, $\gamma=5/3$, Wing Loading 100 lb per Square Foot*

Speed in miles/second	8	7	6	5	4	3	2	1
Lift/weight	−1·56	−1·0	−0·44	0	0·36	0·64	0·84	0·96
Altitude in thousands of feet	216	221	237	∞	219	182	147	108
ρ_0 in lb/ft³	0·40	0·32	0·19	0	0·36	1·14	3·37	15·41
Deceleration, ft/sec.²	28·8	18·5	8·1	0	6·6	11·8	15·5	17·7
Heating, kW/ft²	5160	2900*	1090*	0	596	794	696	397
Heating, kW/ft² 10 lb/ft² wing loading	516	290*	109*	0	60	79	70	40

* May be reduced by use of braking ellipses.

Review of Assumptions.—(*a*) The flow pattern shown in the figure is basically two-dimensional. However, if a wing of high aspect ratio was made on this principle, it would require a tail to make it aerodynamically stable. This tail would be liable to burn off as it would have to be in the main air stream. On the whole, it was felt that spin stabilisation was safer even if unconventional. The spin-stabilised vehicle would be stable even when partly burnt away. In any case, the fundamental concept and calculation would apply equally well to the conventional aircraft, including its tail surface.

(*b*) The tip Mach cones have been neglected. On the cool face this is not very serious, but on the pressure face the Mach number is lower and some pressure losses due to tip effect would be observed. These would have the effect of decreasing the static margin of the vehicle by a calculable amount.

(*c*) *Steady Flight.*—The steady flight case at constant altitude has been calculated. The pilot would and should break contact with the atmosphere frequently between 7 miles per second and 5 miles per second. Below this speed he would be unable to do so, but might prefer to vary the flight path by diving and climbing.

(*d*) *Temperature Rise.*—The condition of the air behind the shock wave is of very high temperature and pressure, but very low density, only four times ambient. The temperature taken up by the solid surface will therefore be somewhat indeterminate and will depend so much on radiation that it was thought undesirable to attempt to calculate it from aerodynamical considerations of boundary layers.

Instead, the work done on the vehicle by the atmosphere has been calculated as drag times velocity and reduced to kilowatts per square foot. An ordinary electric fire element corresponds to about 20kW per square foot and would appear to be an entirely safe value. Perhaps 100kW per square foot would be thought acceptable.

DISCUSSION

Mr. T. Nonweiler, recalling that he had long been an advocate of an aerodynamic re-entry vehicle, pointed out that a spherical object (which had been in favour with some members) would have to suffer colossal decelerations if it entered the atmosphere above the escape velocity. He also drew attention to the severely pessimistic nature of the author's assumption that all the energy dissipated would be absorbed in heating the body: some at least would be transferred to the air, and in fact it had been estimated that the returning "Vanguard" satellite might reach no more than 1100 deg. Cent.

Mr. E. M. Dowlan recalled that positive base pressures had been experienced on bodies in hypersonic flow, which cast doubt upon the existence of the absolute vacuum upon the "cold" face of the vehicle. An explanation of this could be seen in the fact that the shock wave could not in reality be infinitely close to the leading edge, and in the subsonic region there would be flow in both directions from the stagnation point: thus some air would pass to the lower surface of the vehicle. It had also to be borne in mind that the boundary layer would modify the aerodynamics of the body.

Dr. Hilton replied that these effects had been considered: certainly the boundary layer would pass round the nose, but it would be subject to the intense ejector action of the main stream. He believed that it was possible to design for the viscous flow case: he suggested that a "hollow ground" section might, in the presence of a boundary layer, behave as a wedge. He concluded by remarking that Shakespeare had made a remarkable forecast of the behaviour of a satellite in Puck's speech:

"I'll put a girdle round about the earth
In forty minutes."

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

LIMITING DIMENSIONS OF AIR FILTERS FOR INTERNAL COMBUSTION ENGINES AND COMPRESSORS OTHER THAN FOR AIRCRAFT

No. 2806 : 1956. Price 3s. 6d. The limiting dimensions specified in this British Standard apply to air filters which comply with Grades A–B of the companion standard B.S. 1701, "Filters for Air Supply to Internal Combustion Engines and Compressors (Other Than Those Used for Aircraft)." The standard deals with filters whose air flows are within the range of from 10–1000 cubic feet per minute. (This range is based upon non-pulsating air flows. When selecting filters for particular applications due allowance should be made for pulsations). The types of filter to which the standard applies are: round oil bath, with bottom, top and side air outlets, and also with side air outlets and centrifugal pre-cleaner; round, dry and viscous; and dry and viscous filter panels. The standard specifies the screw threads to be used. The method of marking is also laid down. The object of the standard is to quote the foreword, "... to ensure a measure of interchangeability so that, in the event of the required make and type of filter not being available for replacement, an alternative filter can be fitted and used, even if only as a temporary measure."

Metallurgical Topics

Hot-Hardness Tests

HOT-HARDNESS tests have frequently been used to assess the strength of materials at high temperatures, and to explore suitable temperature conditions for mechanical treatment. A sharp drop in hardness with increasing temperature often indicates the upper limit of usefulness of a particular alloy. A certain hardness level may help to fix the most suitable forging temperature or may indicate the possibility of hot rolling. The ease with which a hardness survey of a material or alloy system can be made over a range of temperature with minimum expenditure of material gives hardness tests a distinct advantage over measurements of other mechanical properties.

In measuring the hardness of high-speed tool steels at high temperatures, E. C. Bishop and M. Cohen[1] used a diamond indenter at temperatures up to 593 deg. Cent. in an atmosphere of purified nitrogen without evidence of deterioration of the indenter. The Vickers hardness tester was adapted by F. P. Bens[2] for testing high-strength alloys for gas turbine blades at temperatures up to 925 deg. Cent. by the use of a vacuum furnace and an extension member added to the indenter piston. A standard Vickers diamond was employed and the impressions were measured at room temperature. Measurements of the hardness of electrodeposited coatings at temperatures up to 900 deg. Cent. were made by A. Brenner[3] who used a diamond pyramid indenter mounted on a tungsten rod and surrounded by an inert atmosphere. Russian investigators (M. E. Blanter *et al.*)[4] have determined the effects of various additions on the hardness of nickel at temperatures ranging from room temperature to 1100 deg. Cent. The additions were chromium (0·8–26 per cent), molybdenum (1·07–12 per cent), tungsten (0·8–11 per cent), titanium (1·46–7 per cent), cobalt (1·37–5·15 per cent), and aluminium (0·87 and 1·71 per cent). Hardness/composition isotherms are given for all these alloys. An indication of the results is provided by Fig. 1, which shows the relative hardness of selected alloys at each temperature, the value for nickel at that temperature being taken as 100. Thus, 12 per cent molybdenum increases the hardness to nine to nine and a half times that of nickel in the range 800 deg. to 1100 deg. Cent., 19 per cent chromium to six times in the range 700 deg. to 900 deg. Cent., 4·3 per cent titanium and 11 per cent tungsten to three to four times at about 700 deg. and 900 deg. Cent., and 1 per cent aluminium doubles the hardness between 700 deg. and 900 deg. Cent.: 5 per cent of cobalt produced little relative effect.

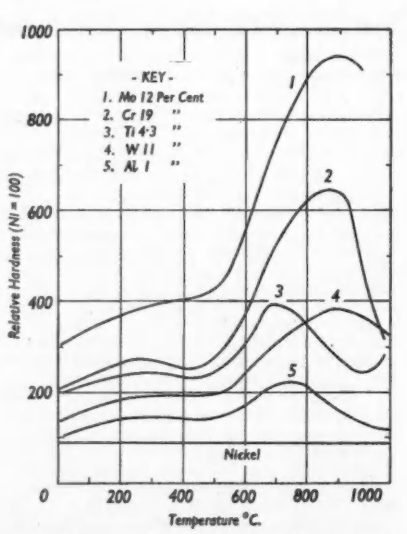


Fig. 1—Influence of alloy elements on the hardness of nickel at different temperatures (Blanter *et al.*)

At very high temperatures the standard diamond indenter is liable to become welded to some materials with the formation of carbides. Protection from oxidation also becomes more difficult. Further improvements in equipment, enabling hardness tests to be carried out at temperatures up to 1650 deg. Cent., have been made by M. Semchyshen and C. S. Torgerson.[5] The principles of the pyramid penetration method have been embodied in a dead-weight loading apparatus in which the indenter, working in an atmosphere of argon, consists of a pyramid of synthetic sapphire, ground to the standard Vickers shape, mounted at the end of a molybdenum rod. The specimen is fastened to a stage which is rotated so that a series of impressions can be made at about ½in from the centre of the specimen which, with the indenter and its support, is heated or cooled in stages within the range room temperature to 1650 deg. Cent. Some typical results obtained with this apparatus are shown in Fig. 2. The hardness curve for pure iron shows the effect of the α to γ transformation at about 905 deg. Cent. and this is an indication of sensitivity of the apparatus. The curve for S 816 (a cobalt-base " superalloy ") indicates that it would have reasonable load-carrying ability at temperatures up to 870 deg. Cent. (as indeed it has), but arc-cast unalloyed molybdenum in its softest condition would be expected to be stronger than this cobalt-base alloy at temperatures above 1000 deg. Cent. The potential merit of tungsten-base alloys to serve as high-strength materials at temperatures above 870 deg. Cent. is suggested by the hardness/temperature curve for tungsten.

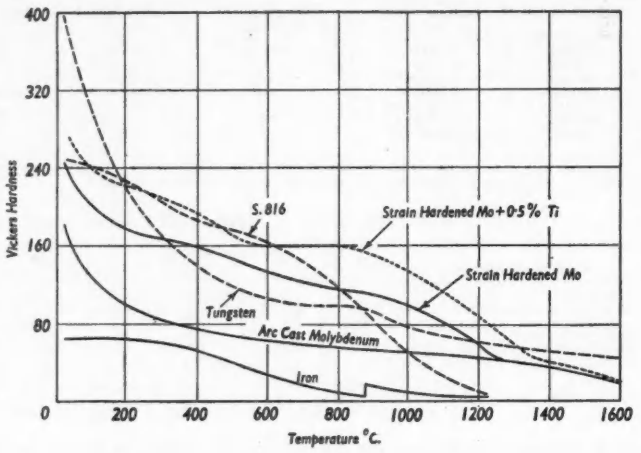


Fig. 2—Effect of temperature on hardness of iron, tungsten, molybdenum and alloys (Semchyshen and Torgerson)

TABLE I.—*Hardness and Stress-Rupture Strength of Strain-Hardened Molybdenum and Molybdenum-0·5 per cent Titanium Alloy*

Testing temperature, deg. Cent.	Unalloyed molybdenum		Molybdenum-0·5 per cent titanium alloy	
	Hardness VPN	Stress to produce rupture in 100 hr., tons/sq. in.	Hardness VPN	Stress to produce rupture in 100 hr., tons/sq. in.
871	112	13·8	156	30·4
982	100	9·8	137	23·7
1093	80	5·8	118	15·2

Preliminary strain hardening by rolling increases the hot hardness of molybdenum up to about 1200 deg. Cent., and the strain-hardened molybdenum-0·5 per cent titanium alloy possesses greater hardness at temperatures up to about 1316 deg. Cent. at which temperature recrystallisation is complete and the effect of preliminary strain hardening is lost. The superior stress-rupture strength at temperatures up to 1090 deg. Cent., conferred by the addition of titanium, is shown in Table I, which also illustrates the value of hardness tests in the preliminary selection of metals and alloys for strength at high temperatures.

HARDNESS SURVEY OF ALLOY SYSTEMS

Hot-hardness tests have been used to survey variations in mechanical properties in the different phases of an alloy system. They have recently been applied for this purpose by W. Chubb, G. T. Muehlenkamp and A. D. Schwope[6] who have carried out a hot-hardness survey from room temperature to 900 deg. Cent. of the zirconium-uranium alloys, interest in which has arisen in connection with nuclear power production. The tests were made *in vacuo* with a sapphire tipped indenter mounted on a stainless steel rod, since in this case the temperatures involved were not excessively high. The sapphire had a Vickers pyramid tip. In general the hardness of the pure metals fell off more rapidly with increasing temperature than did the hardness of any of the intermediate alloys, but the β uranium phase, stable from about 650 deg. to 760 deg. Cent., is much harder than any other uranium-zirconium alloy in that range of temperature. The hardest alloys at room temperature and up to 300 deg. Cent., and in the γ range above 800 deg. Cent. contained about 50 to 60 atomic per cent of uranium. From 500 deg. to 650 deg. Cent., alloys of this composition softened more rapidly than the others, so that the maximum hardness at these temperatures tended to shift towards 30 atomic per cent of uranium, the composition of the δ phase. At 700 deg. Cent. alloys containing upwards of 95 atomic per cent of uranium were unusually hard, with a sudden fall to extreme softness when a rise in temperature brought them into the γ phase field. Though hardness tests cannot be interpreted in terms of ductility, they will, with minimum expenditure of material, indicate relative strength and possibly disclose compositions to be avoided.

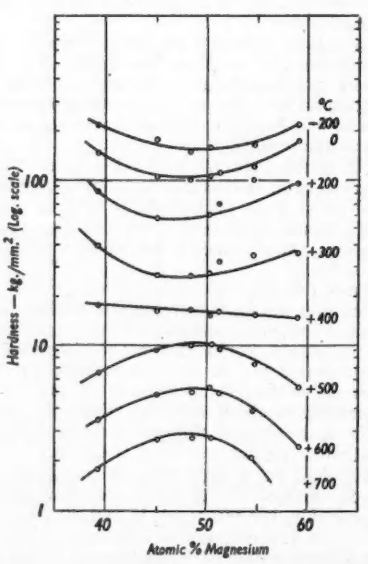


Fig. 3—Hardness/composition isotherms of silver-magnesium alloys (Westbrook)

Another application of hot-hardness tests to the study of an alloy system is illustrated by the

work of J. H. Westbrook[7] who determined the hardness/composition isotherms from −200 deg. Cent. to the solidus of a series of silver-magnesium alloys containing about 40 to 60 atomic per cent of magnesium, with the object of studying the defect structure of the β phase, based on the intermetallic compound AgMg which is characterised by a maximum at 820 deg. Cent. in the melting point curve. At low temperatures, hardness minima were located near the composition AgMg. As the testing temperature was raised, the hardness/composition isotherms flattened out and the minima ultimately reversed at about 400 deg Cent. to become maxima at the stoichiometric composition, as shown in Fig. 3. This behaviour was held to be due to lattice defects increasing with departure from the stoichiometric composition, these defects being a strengthening factor at temperatures which are a low fraction of the melting point, but becoming a weakening effect at higher temperatures as a result of increased diffusion rates. These assumptions were also applied in an attempt to explain the behaviour of some other intermetallic compounds which show minima at the stoichiometric composition in the hardness/composition curve.

It seems clear that hot-hardness testing may find increasing application in investigations of alloy constitution.

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[5] *Trans. Am. Soc. for Metals*, 1957, Vol. 50, Preprint No. 12.
[6] *Trans. Am. Soc. for Metals*, 1957, Vol. 50, Preprint No. 2.
[7] *Journal of the Electrochemical Society*, June 1957, page 369.

Small Additions to 70 : 30 Brass

THE influence of small additions of various elements on the mechanical properties of 70 : 30 brass at high temperatures has been examined by J. Herenguel and M. Le Nouaille.* Brass of this composition shows a certain fragility under hot-working conditions and low values of creep stress at high temperatures. The main object of the investigation was to find the addition which would most effectively combat the tendency of 70 : 30 brass to intergranular rupture under stress at high temperatures without notably changing the other properties of the brass or its transformation characteristics. In addition to mechanical properties at room temperature, time to rupture and elongation at fracture under stress in air were determined at 300 deg. to 500 deg. Cent.

Specific effects could be classified under the following headings :—

(*a*) Additions which improved intergranular cohesion without modifying creep strength : phosphorus, cadmium, tin and cerium.

(*b*) Additions which improved resistance to creep without modifying intergranular cohesion : chromium, beryllium, nickel, silicon, silver, aluminium and manganese.

(*c*) Addition simultaneously improving intergranular cohesion and resistance to creep : magnesium.

(*d*) Additions without notable effect on properties at raised temperature : lead (0·05 per cent), selenium and tellurium (0·10 per cent).

(*e*) Additions which reduce intergranular cohesion : bismuth, arsenic and antimony. Bismuth is the most detrimental. Antimony has a feeble but disadvantageous effect. In the presence of arsenic, which has some value in that it diminishes dezincification in the corrosion of brass, deformation at a relatively high temperature (about 900 deg. Cent.) is recommended to avoid brittleness.

The most outstanding of these additions were :

Phosphorus (0·01 to 0·05 per cent), which considerably improved intergranular weakness without sensibly affecting other properties.

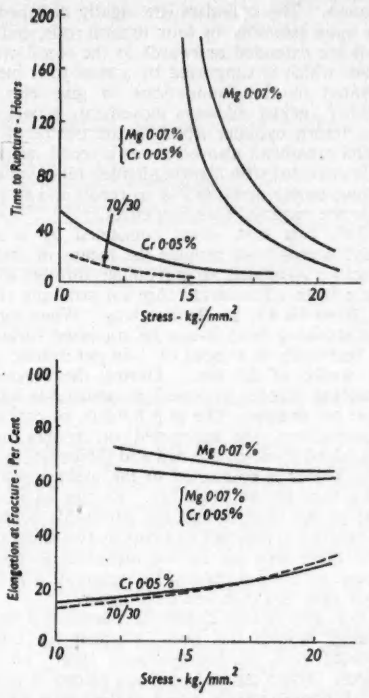
Cadmium, which had a similar effect, but only in amounts of the order of 0·5 per cent.

Magnesium (0·05 to 0·08 per cent), which considerably improved intergranular cohesion and also increased resistance to creep. It was the only addition giving these two effects simultaneously.

Chromium (0·05 to 0·10 per cent), which increased resistance to creep rather more than magnesium did, but had no influence on intergranular cohesion.

A few brasses to which two elements had been added simultaneously were examined, viz., P 0·01+Cr 0·10 and Mg 0·07+Cr 0·05. In the former the effect of chromium was eliminated and that of phosphorus partially neutralised. It seemed probable that the phosphorus combined with the chromium and that the compound had an action rather like that of phosphorus. In the latter the effect of magnesium was predominant and the alloy behaved as if the chromium were not present, as indicated in the diagram below.

In practice, the additions of greatest interest in preventing the incidence of intergranular



Influence of additions of magnesium and chromium, separately and together, on the time to rupture of 70 : 30 brass at 300 deg. Cent. and on its elongation at fracture

rupture in the course of use or treatment at raised temperatures would appear to be 0·01 to 0·05 per cent of phosphorus or 0·05 to 0·08 per cent of magnesium. The addition of phosphorus has, of course, been a well-known practice, dating from the work of Genders and Bailey† twenty-five years ago. Such additions improve the capacity for hot working and enlarge working temperature limits. At the same time, the risk of intergranular cracking under stress at high temperatures, with all the direct and indirect consequences of the formation of such defects, is considerably reduced.

High-Temperature Properties of Cold Worked Austenitic Stainless Steels

WORK-HARDENED austenitic stainless steels have been widely used to provide corrosion-resistant, high-strength materials for structural components which operate at atmospheric temperature, but only limited attempts have been made to extend their use to elevated temperatures, mainly because of lack of information about the effect of cold working on the strength and structural stability of these materials when subjected to stress at high temperatures.

A paper by R. A. Lula, A. J. Lena and H. M. Johnson* is concerned with the results of an investigation into the effect of cold working on the high-temperature properties of three austenitic stainless steels, viz. 301, 305 and 310 with chromium : nickel ratios of approximately 18 : 8, 18 : 12 and 25 : 20. It was found that the rupture strength of these steels at elevated temperatures could be improved by cold working, provided that the degree of cold work and the conditions of exposure were not conducive to extensive recrystallisation. The increase in strength brought about by cold working was greater in magnitude the lower the testing temperature. As is shown in Fig. 1, a 50 per cent improvement in the 100-hour rupture strength at 649 deg. Cent. can be obtained by cold work-

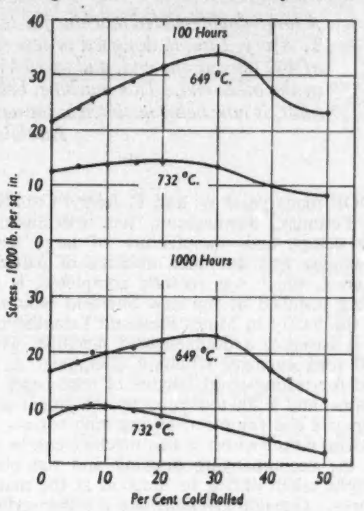


Fig. 1—Effect of cold rolling on the stress-rupture properties at 649 deg. and 732 deg. Cent. of 301 austenitic stainless steel (carbon 0·11, chromium 17·83, nickel 7·17 per cent)

ing, whereas at 732 deg. Cent. the maximum improvement is 10 per cent. The amount of cold work giving the greatest benefit, in general, decreased with increasing time at a given temperature or with increasing temperature at a given time. This also is illustrated in Fig. 1. After more than the optimum amount of cold work, recrystallisation occurs more readily, and recrystallisation results in a substantial decrease in high-temperature strength. The initial improvement in rupture strength is gradually lost with increasing amounts of recrystallisation, and the stress-rupture values of the cold-worked materials drop below those of the annealed steels by the time recrystallisation has proceeded half way to completion. As indicated in Fig. 2, some

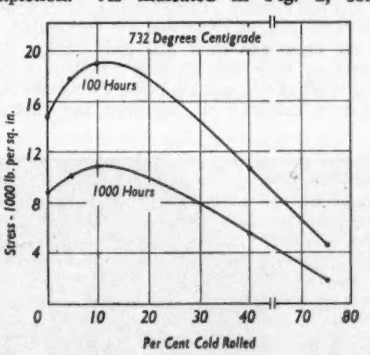


Fig. 2—Effect of cold rolling on the stress-rupture properties at 732 deg. Cent. of 310 austenitic stainless steel (carbon 0·065, chromium 24·58, nickel 19·86 per cent)

improvement is obtained in the 25 : 20 alloy which has been cold worked 5 or 10 per cent, but the rapid recrystallisation of the more severely cold-worked material had a detrimental effect on the strength at high temperatures, which soon falls below that of the annealed material. The investigation included a microscopical examination of the steels which had been tested, and as a result of this it was concluded that the decrease in rupture strength due to recrystallisation was attributable to the structural changes that occur. These included changes in grain size and modification of carbide distribution. In the 25 : 20 alloy there was, in addition, accelerated formation of the sigma phase. Martensite produced by cold rolling of the unstable austenitic stainless steels, such as the 18 : 8, transformed to austenite at the testing temperatures and did not contribute to high-temperature strengthening.

The optimum amount of cold work varied greatly for the three steels examined.

* *Revue de Métallurgie*, May, 1957, page 354.

† "The Casting of Brass Ingots," B.N.F.M.R.A., 1934.

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Wire Rope Testing Machine

A large double-ended machine for testing wire ropes, recently completed by W. and T. Avery, Ltd., is designed to test ropes up to 9ft 9in long to a maximum loading of 400 tons at one end, and up to 170ft long to a maximum loading of 200 tons at the other end. This machine, believed to be one of the largest of its kind yet built, is now being installed in the new laboratories of the Safety in Mines Research Establishment at Sheffield.

FOR many years W. and T. Avery, Ltd., Soho Foundry, Birmingham, has specialised in the design and manufacture of large testing machines, and one such machine of particular interest, which was recently completed, is now being installed at the new Sheffield laboratory of the Safety in Mines Research Establishment. It is basically a double-ended machine, with a 400 tons capacity straining equipment at one end for testing short lengths of wire ropes and chains, and a 200 tons capacity equipment at the opposite end for proof testing long ropes. The general construction of this machine can be seen in the accompanying drawing and the photographs taken during its erection at the makers' works. One end has built into it a twin-cylinder straining unit, which is used for testing wire ropes or chains from 3ft 9in to 9ft 9in long over a 2ft 6in stroke, up to the maximum loading of 400 tons. The other end incorporates a single-cylinder straining unit of 200 tons maximum capacity, which has a 9ft stroke and is used for the proof testing of ropes from 120ft to 170ft long. An indicating equipment and hydraulic pumping set situated adjacent to the twin-cylinder straining unit is used for operating and recording both of the straining systems.

In the twin-cylinder straining unit a rigid cast steel head provides the support for the forged steel cylinders and rams which apply the load. The rams are precision ground to a close sliding fit in the cylinders so that they function effectively without the use of any form of hydraulic packing. At their outer ends the rams are connected through struts to a heavy crosshead carried by self-aligning rollers running on machined ways on the bed casting. These loading struts between the rams and the crosshead are ball ended, and at the crosshead their ball ends have a crank extension by which, through a system of Belleville washers and tension bolts, the weight of the rams is balanced to minimise the effects of friction. The cylinders are rigidly clamped to the main assembly by four tension rods, and the rods are extended rearwards to the recoil crosshead, which is supported by a steel joist incorporated in the foundations to give effective rigidity against sideways movement. A packingless return cylinder fitted in the centre of the recoil crosshead also serves as a recoil cylinder. It is provided with a spring-loaded relief valve to relieve excess pressure due to recoil and to provide the required damping effect.

Two cast iron struts connected by a substantial crosshead provide the means of attachment for an adjustable grip holder, through which there is an adjustment range for straining ropes of from 3ft 9in to 9ft 9in long. When setting the straining head it can be traversed forwards or rearwards at a speed of 14in per minute over its stroke of 2ft 6in. During the rearwards straining stroke its speed is adjustable up to 2½in per minute. The grip holders, of cast steel construction, are supported on rollers on a machined track on the bed and the straining end grip holder is connected to the main crosshead by a high tensile shear pin. As can be seen in one of our illustrations, the adjustable holder is connected to the loading struts by two shear pins, and these pins are moved outwards to engage holes at 1ft 8in centres by means of a ratchet lever operated rack and pinion gear.

For grip holder mounting purposes a set of special moulds has been provided for casting tapered ends on the specimen length of wire ropes. These tapered ends are placed in appropriate conical inserts, which, as the load is applied, lock in the tapered bores of the grip heads. Adaptors are also provided for the grip holders to enable chains and shackles to be tested on the machine.

As already mentioned, a single-cylinder straining unit at the opposite end of the machine is used for the proof testing of wire ropes from 120ft to 170ft long, and the two ends of the machine are rigidly coupled together by a cast iron bed made up of 14ft long sections. This straining unit incorporates a single-acting cylinder and ram with a 9ft stroke, capable of imparting a maximum load of 200 tons on a rope. A single-acting return cylinder and ram is fitted in this assembly, and the two units are connected to a straining crosshead which slides along a machined cast iron bed-plate. The crosshead is operated at a straining speed of 5in per minute, and has forward and return setting speeds of 28in and 15in per minute respectively. A spring-loaded relief valve fitted to the return cylinder relieves excess pressure due to recoil when a specimen breaks, and the oil which escapes from the system after recoil flows into a sump tank instead of being piped back to the pump tank.

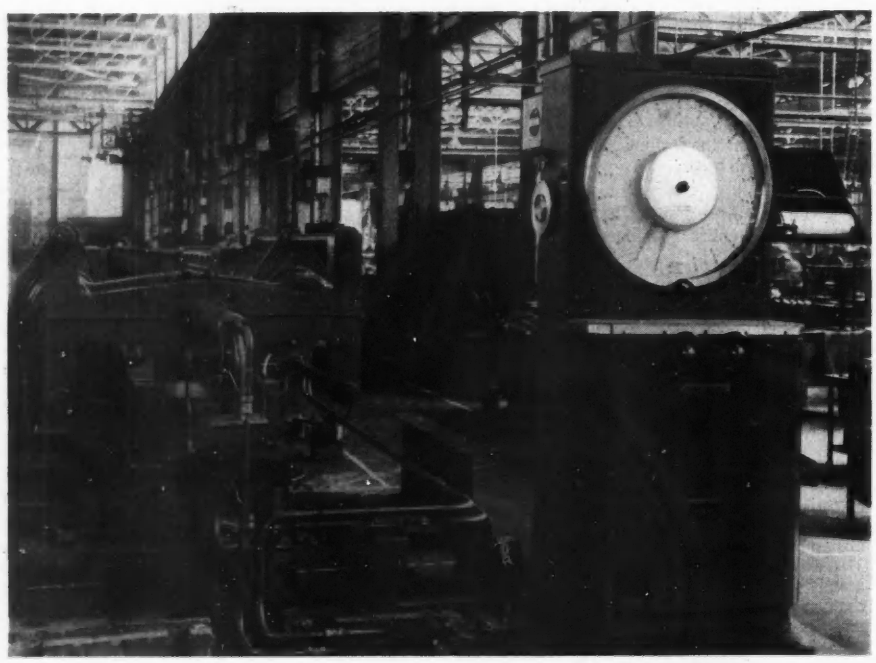


Fig. 1—Rear of 400-ton capacity twin-cylinder straining equipment for wire rope testing. The autographic recorder is mounted on the right-hand side of the control and load indicating cabinet in the foreground

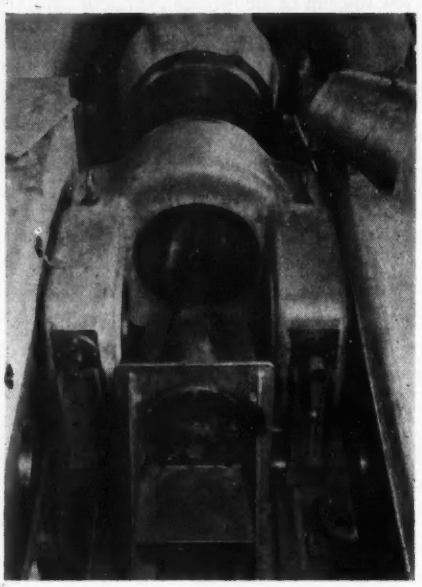


Fig. 2—Adjustable grip holder with capped wire rope in position before fitting of the top half of split conical grip

A hand-operated double-acting pump is provided to drain the sump tank, when necessary.

Tension racks supported on rollers on the bed frame longitudinal members are attached to this straining crosshead, and have shear pin location holes bored at 2ft 6in centres along their 50ft length. A grip holder fitted with rollers running on a machined track in the bed can be attached at any required place to these tension racks by shear pins operated by a rack and pinion gear.

The main grip holder is fitted with a rope holder of 200 tons capacity, which incorporates a recoil block and accommodates the split conical adaptors for the wire ropes. Long ropes under test are coupled between this holder and that of the 400-ton straining equipment at the far end of the machine. When this form of test is to be carried out the rams of the 400-ton equipment are first extended a few inches to provide a resisting column of oil for measuring purposes in the indicating apparatus.

As can be seen in the drawing, the pumping and valve gear is to be installed, in a pit below the indicating cabinet, in a separate chamber at the heavy straining end of the machine. In the design of this gear special provision has been made to ensure the requisite degree of close control which is essential in this class of testing. Separate high and low-pressure pumps are used for straining and setting, the high-pressure pump being designed to deliver up to 2·5 gallons of oil per minute at a pressure of 3360 lb per square inch. Two small gear pumps mounted on the same bed-plate are used for exhausting any hydraulic fluid leaking from the cylinder at the 400-ton straining end of the machine. Oil for this hydraulic system is stored in a large rectangular tank above the pumps.

Control and Load Measuring Equipment

A combined selector and setting valve mounted on the cabinet front is lever-operated and spring

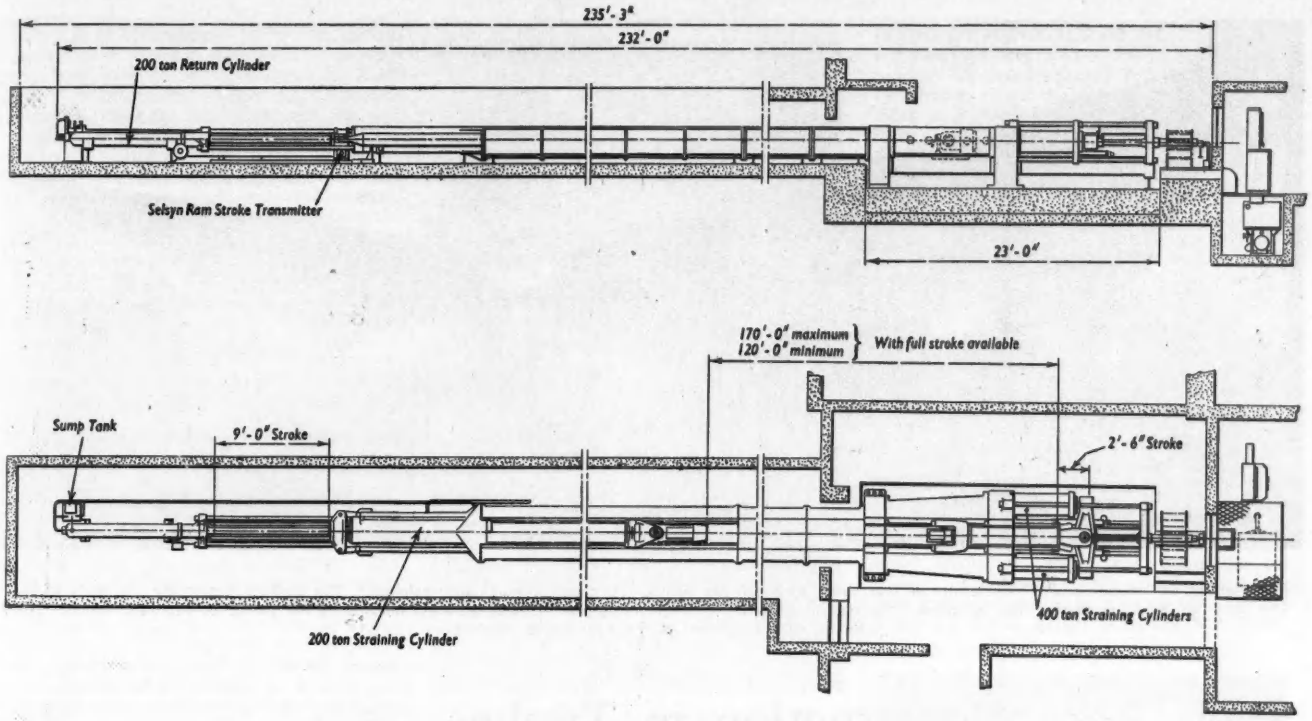


Fig. 3—General arrangement of wire rope testing machine of 200-ton and 400-ton capacity

loaded into the neutral position. It can be latched for the set and return movements at the 400-ton capacity end of the machine or for those of the 200-ton capacity unit at the other end. The lever is held positively by a spring-loaded index in either one of the positions in which the load can also be applied. Two control valves are provided, one for applying the load and the other for its release. Each valve has means of both coarse and fine adjustment. The coarse adjusting wheel rotates almost a complete turn and is fitted with a graduated disc indicating the degree of opening. A knob concentric with this wheel provides the means for fine adjustment of rate of flow.

The constant-flow loading control valve gives a constant speed of loading on an elastic specimen from zero to full load without need for adjustment. A load may be held at any desired value by closing both valves for periods up to about half a minute or sufficiently long for taking extension readings. For longer periods a load may be held by the precise adjustment of the fine controls to compensate for any tendency it may have to increase or decrease.

At the 400-ton end of the machine there is an extension scale in the form of a 36in rule graduated in tenths of an inch. Movement of the ram at the other end of the machine over its 9ft stroke is transmitted through a Selsyn equipment to the indicating unit, where it is recorded on a dial graduated in 1in increments over 108in.

The indicating unit can be seen in one of the illustrations; it is of fabricated steel construction. In it a base section provided with a desk houses the valve controls and electrical gear, and the upper section encloses the pendulum and chart mechanism. A pendulum resistant which forms the basis of the load measuring mechanism follows standard Avery practice, being of proved accuracy and reliability and unaffected by temperature changes and hysteresis. The machine is arranged with four load ranges, which are selected by the setting of a capacity change wheel centrally positioned below the chart. As the capacity is changed the appropriate set of figures is brought into view on the chart, thus eliminating the possibility of error in reading. The graduations are widely spaced on a maximum reading line diameter of 23in. On the indicating dial the scale loading up to 400 tons is shown in increments of 1 ton; on the second scale 200 tons in 0·5-ton increments; on the third scale 80 tons in 0·2-ton increments; and on the fourth scale 40 tons in 0·1-ton increments.

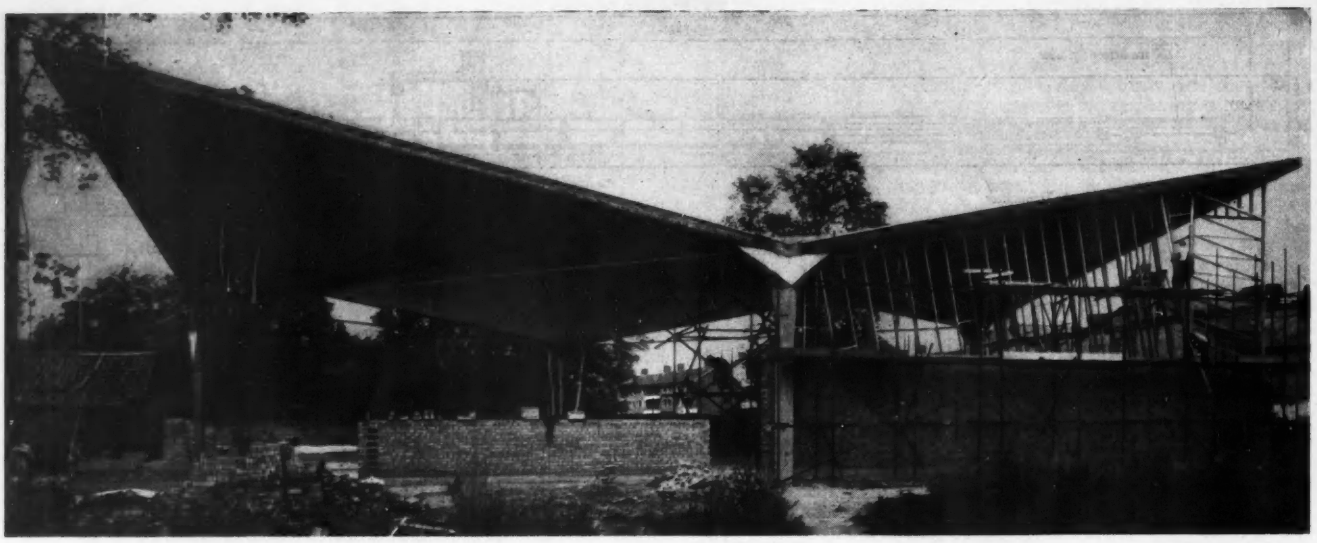
During the straining operation the load applied on a specimen is transmitted hydraulically to a proportional ram, which applies load to the pendulum unit through an intermediate lever system. This proportional ram is continuously rotated to eliminate friction. The unit is fitted with a hand reset maximum load pointer, and an electrical overload trip mechanism is designed to operate on all working ranges.

An autographic recorder is fitted on the right-hand side of the indicator cabinet and its pen is operated by the load measuring mechanism whilst the drum is turned by the extension of the specimen being strained. If required, reducing scales of 4 to 1, 2 to 1, or 1 to 1 can be recorded on the drum by the attachment of a cord to the grip holder.

When erected the machine will have an overall length of 232ft, but, as the building at the Safety in Mines Research Establishment has not yet been completed, only the 400-ton straining end with a 25ft bed is now being installed. The other bed sections and 200-ton straining equipment are being completed by the makers ready for installation when the second part of the Establishment's building programme is put in hand. It is of interest to note that W. and T. Avery, Ltd., now have in hand an order for a similar machine of 500 tons maximum capacity for installation at the National Coal Board, Central Engineering Establishment, Burton-on-Trent.

Fig. 4—400-ton straining end of machine during assembly

CAREERS IN CIVIL ENGINEERING.—A recruitment campaign to attract boys leaving school to careers in building and civil engineering, has been started by Holland & Hannen and Cubitts, Ltd., 1, Queen Anne's Gate, London, S.W.1. This firm is inviting up to six boys, between the ages of sixteen and eighteen, from each of 120 secondary grammar and public schools in the London postal area, to attend a two-day course in London during September entirely at the company's expense. The only necessary qualification is G.C.E. with five passes including English and mathematics. If this "pilot" scheme is successful the company intends to hold similar courses at its area offices throughout the country. The London course, which begins on September 11, is planned to show how modern buildings are erected and the planning and research work involved, and is designed to interest the boys in careers in project management. Visits will be made to various sites in London and the Home Counties and will end with a discussion on the many opportunities offered in the building industry.



The building at Wilton consists structurally of four shells, each 57ft 5in square. They are carried by four columns. The tie-bars across the diagonals of the two shells on the left-hand side may be noted. The vertical tie near the left-hand column in the illustration holds down the corner of the shell against wind forces, until completion of the walls of the building

Shell Roof Construction in Timber

A timber roof giving a clear floor space of about 110ft square, and composed of four anticlastic shells, has just been erected at Wilton, near Salisbury. The roof has been designed by the Timber Development Association, in conjunction with Mr. R. Townsend, and is considered to combine economy with good appearance.

MUCH of the research effort at present being expended by the Timber Development Association is directed towards the more rational use of timber in structural engineering. Noteworthy progress has been made, for example, in ascertaining the best form of triangulation, and also the best method of detailing for timber trusses, and it has already been claimed that over certain ranges of span, timber trusses are more economical than corresponding roof trusses which utilise other structural materials. It is characteristic, however, that research of this kind often leads to unexpected conclusions. In this case, research work on shell roofs in timber is now at a promising stage of development, and the indications are that timber is likely to prove itself to be a most advantageous material, economically, and possibly also from the point of view of the structural theorist, for shell roof construction. Thus the traditional use of structural concrete, almost without exception, for shell roof construction, is now challenged.

We were recently able to see the first full-scale shell roof built in this country in timber, which is at the Royal Wilton carpet factory at Wilton, near Salisbury. The structure of the roof itself consists of four similar shells, giving a clear floor space 110ft square, and is now complete. Work is still in progress, however, on the walls of the building. This particular form of shell was, we understand, not in the immediate research programme of the T.D.A. It was called for in this case on the initiative of the architect, Mr. Robert Townsend, of Bath, and the Association's work was adjusted to take full advantage of the opportunity thus presented.

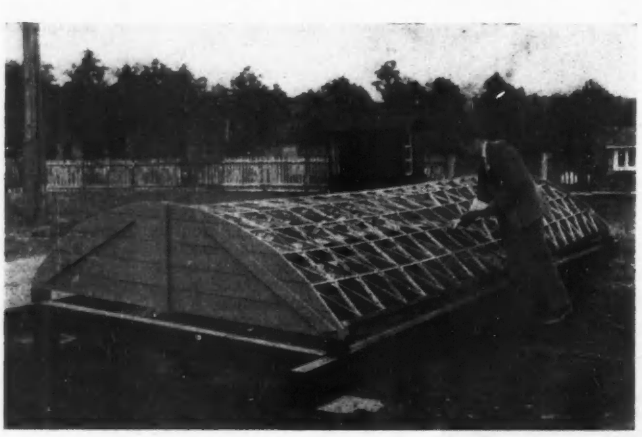
The Association's research up to that time had been concentrated on a barrel vault shell. The aim was to build it by bolting together large braced panels. In contrast, the doubly-curved shell of the Wilton roof consists of three layers of boards. It will be interesting to see which of these two forms eventually finds the wider application, or whether some third pattern will eventually supersede them. The two designs are clearly shown in the illustrations of the structural models ; our subsequent description concerns the full scale structure at Wilton, and its design.

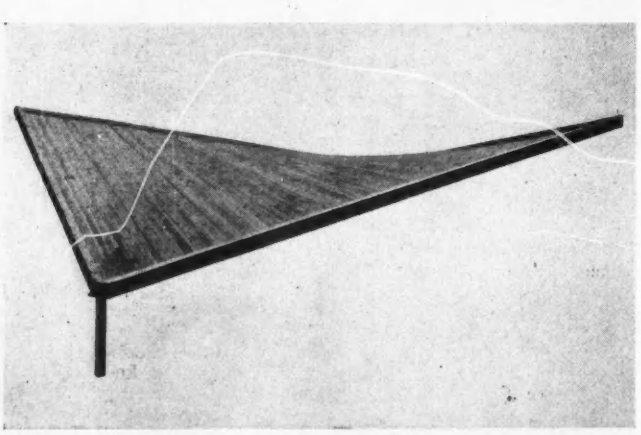
The Anticlastic Shell

The particular form of shell used at Wilton is an anticlastic shell—the simplest in this category—defined by the equation $z=kxy$. The illustration of the model gives the best idea of the surface thus defined, which can be explained, in words, as follows. Take a square and lift two diagonally-opposite corners ; then join corresponding points on the sides by straight lines. The new surface thus obtained is that of the shell—a hyperbolic paraboloid. The curve of the roof across one diagonal of the " square," from one raised corner to the other, is concave, and across the other diagonal, from one low corner to other, it is convex. The " sagging " section gives tension in the roof, and the " arching " section gives compression. Four edge beams stiffen the sides of the " square," and these beams are in compression. The " square " is supported at the two low corners and, as may be deduced, the reaction on these two supports tends to thrust them apart, so a tie bar is put between them, under the " arched " diagonal.

This shell is not a new shape, and a timber shell of similar form has been erected by the American architect Catalano, and several concrete shells of this kind have been erected. Some of our readers may recall the design submitted for the competition for Coventry Cathedral which proposed a shell of this kind, to a much larger scale of course, in prestressed concrete; this latter design is described in the proceedings of the 1951 symposium on statically indeterminate structures in prestressed concrete published by the Cement and Concrete Association.

The particular novelty of the building at Wilton is that four of these " square " shells have been grouped together to enclose the building. Because each shell needs two supports only, the whole roof can be carried on four columns, one at the mid-point of each side of the





Quarter scale structural models of shell roofs in timber. (Left) The conventional barrel vault shell, formed from braced panels. (Right) The doubly curved shell, four full-scale versions of which form the Wilton roof. Note that the shell is supported at two corners, which are connected by a tie rod

110ft square of the building. Thus even though the individual shell spans only 57½ft, an uninterrupted floor area is provided over the 110ft square. The illustration of the roof shows this arrangement, the edge beams between the four basic shells being clearly visible, meeting at the vertex in the centre of the building. With this layout, the headroom varies between 18ft and 30ft. Since this variation—due to the basic shape of the shell—may be more critical than the ability to span a given distance, the advantage of grouping four shells in this way is apparent. We also illustrate one of the reinforced concrete columns carrying the roof, and the tubular steel scaffolding in position ready for the timber boards.

Construction in Timber

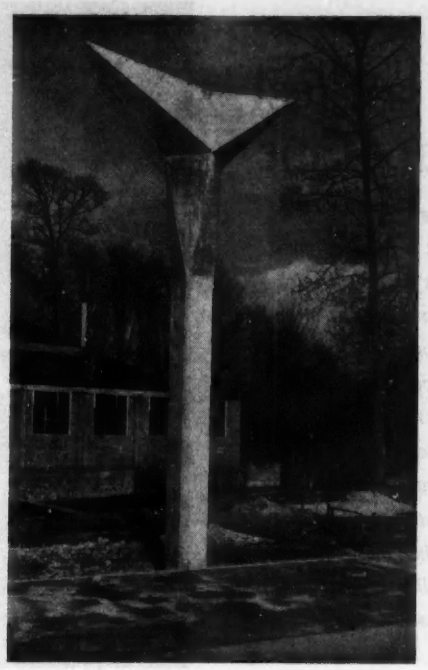
Shells built in timber have the advantage of low self-weight. The shells at Wilton each consist of three layers of tongued and grooved European Redwood boarding. The timber is fifth quality (i.e. about the cheapest obtainable) and the boards are ¾in thick by 5in wide. The top and bottom layers were placed straight (i.e. parallel to the sides of the shell) and the central layer ran diagonally, along the parabolic surface. The shells are thus 1¾in thick. The lower and middle layers of boarding adhere with "Bostik," and the top layer is nailed to them to within ¼in of the lower surface. A 6ft strip round the outer edge of each panel is glued with "Aerolite 300" urea adhesive in addition to nailing.

The underside of the roof is treated with two coats of a p.v.a. glaze sprayed on. The upper weather surface consists of two layers of "Ruberoid," the bottom layer being random nailed and the top layer mineral surfaced and stuck with a bituminous adhesive.

Each of the edge beams consists of twelve laminæ of 1in by 10in unsorted redwood glued with "Cascophen" resorcinol adhesive, and is 58ft 8½in long with a twist of 12 deg. to accommodate the line of the boarding. The beams are 12in deep with six laminæ above the boarding and six below, and they are glued to the boarding.

A 2¾in diameter mild steel tie rod runs diagonally across under each panel and bears against the corner joint of the two edge beams at each corner. The tie rods are somewhat heavier than necessary but were used as they happened to be available. Over 100,000 nails 1¾in long of 12 s.w.g. were used to secure the roof boarding. Each shell covers a square of 57ft 5in, and the entire roof covers a square of 114ft 10in.

There is a tendency for the upper corners of each shell to rise under load. This is resisted effectively by the dead load in a structure of this size, but during construction, before the sheltering effect of the walls is available, the upper corners are anchored to the ground as a precaution against the effects of wind loading.



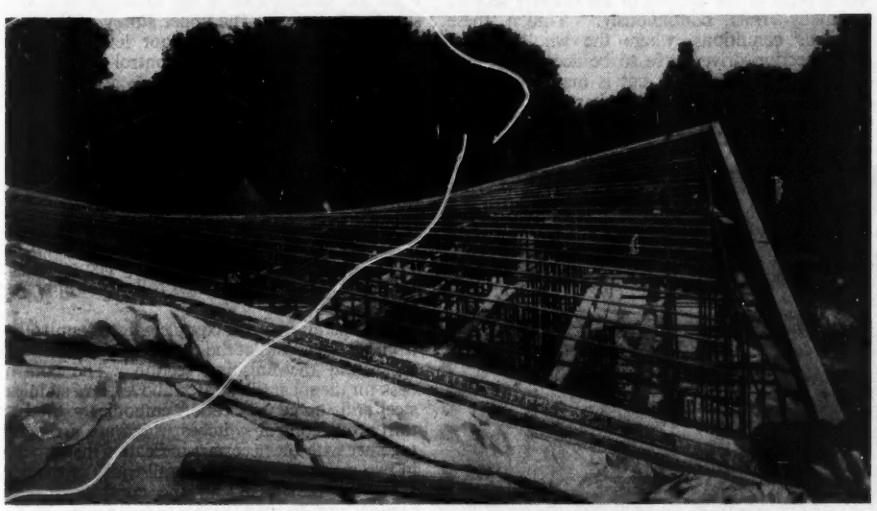
Reinforced concrete column. Each shell needs two supports; by arranging each column to carry adjacent corners of two shells, the entire roof is carried on four columns, spaced at the mid-points of the sides of the 110ft square enclosed by the building

Structural Design

The weight of the timber shells of the Wilton roof is 5 lb per square foot due to the timber, plus 2 lb per square foot due to the roofing felt. The design load in addition to this self-weight, was taken as 20 lb per square foot. With this total load of 27 lb per square foot, the stress in the shell, although varying somewhat, averages about 175 lb per square inch. The corresponding total force in the diagonal tie is 80,000 lb, and in each edge beam 57,000 lb, giving an edge-beam stress of some 600 lb per square inch.

Initial tests were carried out on the quarter scale model before the roof was erected. Since little is known about the structural behaviour of anticlastic shells, a further programme of tests is to be carried out on the model. These tests, we understand, will concentrate on investigating the behaviour of the shell and measuring deflections when point loads and combinations of loads are applied, and will also investigate the ultimate load behaviour of the shell.

The Wilton roof was built by direct labour for the Wilton Royal Carpet Company, who will use it as a weaving and finishing shed for broad loom carpets. The Timber Development Association has given figures of cost for the structure, which, it is pointed out, are about half the normal cost of buildings with this floor area. The cost of the roof, including the scaffolding and everything above the column heads, works out at less than 10s per square foot, we are informed, and of the whole building, without lighting and heating, under 28s per square foot of covered area.

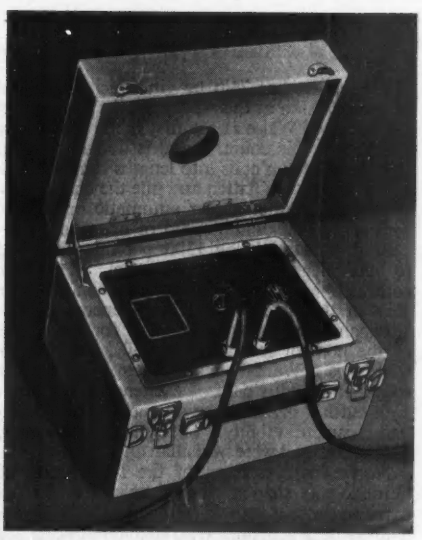


Scaffolding set out for forming the hyperbolic paraboloid of the shell. The generators of the shell are straight, so setting out the scaffolding is simple. The edge beams are already in position

Octave Band-Pass Filters

We illustrate a set of octave band-pass filters made by the Telephone Manufacturing Company, Ltd., Transmission Division, Cray Works, St. Mary Cray, Orpington, Kent.

This set of octave band-pass filters is designed for separating the sound energy contained in any one of the eight octaves in the range 37·5 to 9600 c/s from that contained in the whole of the audio frequency range, thus permitting the analysis of acoustic energy distribution. The performance aimed at complies with the requirements set out in British Standard B.S. 2475 : 1954 and the instrument is substantially in accordance with American Standards Association Specification No. Z24.10-1953.



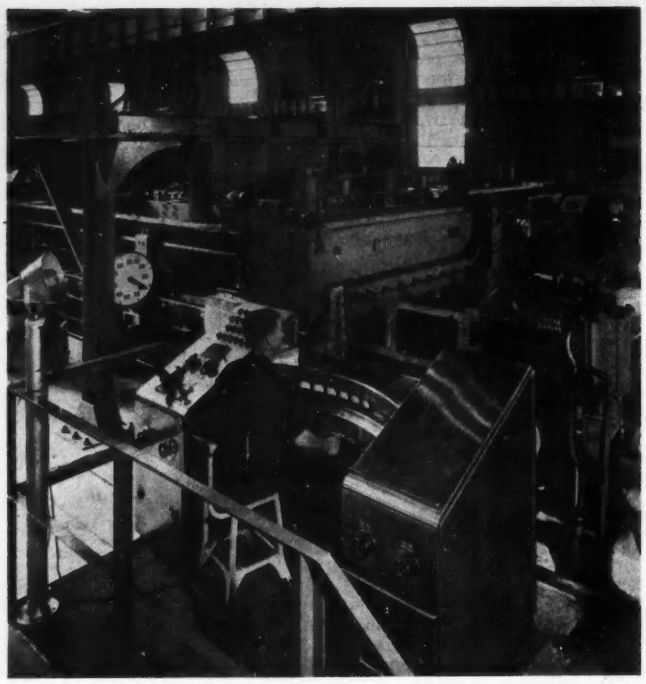
The set of octave band-pass filters illustrated here is designed for separating the sound energy in any one of eight octaves, (37·5 to 9600 c/s) from that contained in the whole audio-frequency range

Each range is selected by a switch and a ninth position provides a "through" circuit equalised to the minimum pass-band attenuation of the filters. The filters are intended to operate with unbalanced resistive terminating impedances of 600 ohms and have a maximum rated power-handling capacity of 1mW. The specified characteristics are as follows.

The minimum pass-band insertion loss of each filter is within the limits 4 dB ±1 dB. The discrimination at one-eighth octave below and above the lower and upper cut-off frequencies respectively does not exceed 3 dB. At one octave the discrimination is at least 25 dB and at three octaves at least 55 dB in the lower stop-band and 60 dB in the upper stop-band. The instrument measures 7¾in by 12½in by 9¾in, weighs 24 lb, is designed for use in tropical climates, and is finished in grey stoved enamel to British Standard 381 shade 31.

Institution of Structural Engineers.—The fiftieth anniversary conference of the Institution is to be held in London from October 7 to 10, 1958. The theme of the conference will be "The Future of Structural Engineering."

Electrical Drive of a Steel Works Cold Cut-up Line



Much of the industrial demand for steel plate in gauges up to ½in is now met by material produced from high-speed continuous rolling mills. Until recently plates over ⅜in thick were obtained either from the mill as fly-sheared lengths, or as lengths of plate processed through the orthodox cooling bank and end shears. Either method restricted the potential capacity of a fast-moving continuous strip mill. The Steel Company of Wales, Ltd., has recently extended the use of coilers to cover all gauges up to and including ½in, and it has therefore been necessary to design and install a cut-up line capable of decoiling, flattening and shearing these thicker gauges. The electrical equipment for this line is described; the control desk for the shear is illustrated here.

THE cut-up line 74in by ½in which is now in commission at the Abbey Works of the Steel Company of Wales is the first of its kind to be installed in this country, and is designed to cut strip from 15-ton coils into lengths ranging from 4ft to 36ft and to flatten and pile the cut lengths. It can be operated under automatic or manual control, the maximum speed of operation when cutting ½in steel being 150ft per minute, rising to 250ft per minute for ⅛in steel. The main contractor for the electrical plant and control gear in this installation, The General Electric Company, Ltd., was responsible for the design of the control scheme. Basically, this control scheme is a Ward-Leonard system operating in conjunction with control exciters which enable high cutting speeds to be attained with accuracy and complete stability. The consulting engineers for the contract were McLellan and Partners.

At the entry section of the line (illustrated here) coils of strip are loaded by means of a coil carriage on to a pay-off reel, which is coupled to a 40kW drag generator used to maintain constant tension in the strip during its passage through the section. On leaving the reel the strip enters a processer (which flattens the material before shearing) and then passes to the entry tables and through a pair of pinch rolls to the Head Wrightson electrically driven up-cut shear. After shearing, the sheets pass to the delivery section of the line, which comprises the shear gauge tables, a roller leveller, a further pair of pinch rolls, an inspection table with automatic rejection and a run-out table from which the finished sheets are piled ready for removal.

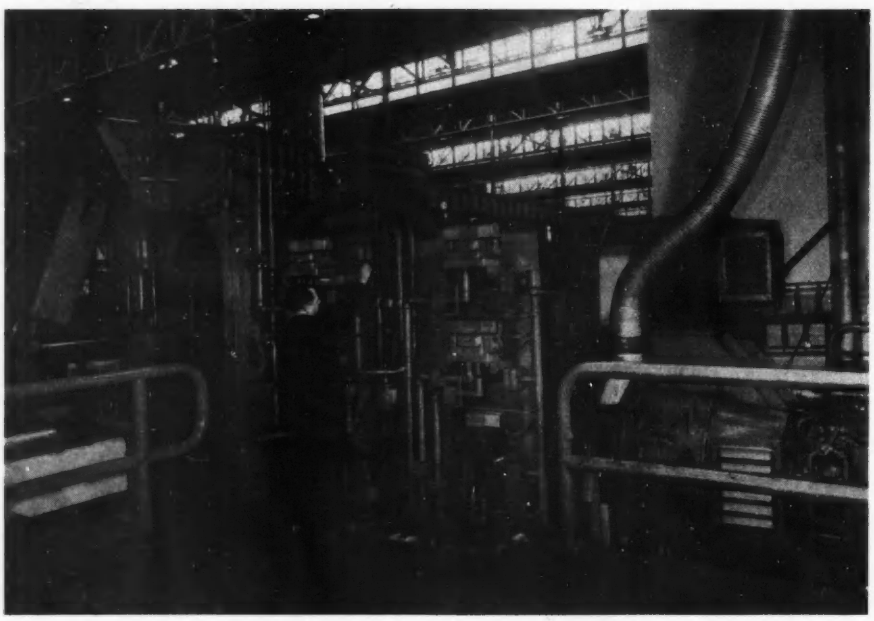
The control scheme provides for automatic operation, besides the usual facilities for manual control, threading and inching. When automatic operation is used, the whole of the entry section of the line stops each time a sheet is sheared ; the shear gauge table starts and stops with the entry section, but the rest of the delivery section normally runs continuously. Under these arduous conditions, where the whole of the entry section drives have to be accelerated and decelerated each time a cut is made, the rapid response of the control exciter system is an important factor in enabling high production to be maintained from the cut-up line.

The d.c. power supplies for the various drives are obtained from a motor generator set consisting of a 700 h.p., 3·3kV induction motor, direct coupled to two 0/300kW, 0/400/500V d.c. generators. This m.g. set also includes a 3kW booster which is connected in series with the drag generator, and a 15kW exciter with a constant-voltage output which provides the excitation for the motors driving the cut-up line.

The four-machine exciter set for the control of the cut-up line is driven by a 10 h.p., 415V squirrel-cage motor, and includes a five-field exciter associated with the entry side generator, a similar exciter for the delivery side generator, and a four-field exciter for the drag generator. This exciter set is installed, together with the main d.c. switchboard, in the basement of a two-storey substation. The upper storey of the substation, which is at mill floor level, provides accommodation for the d.c. control gear.

The drag generator and the eight d.c. motors driving the various sections of the line are forced-ventilated machines with separately excited fields. Cooling air is fed to each machine from a common air supply, either by trunking or by ducts in the foundation blocks, and is exhausted through louvred apertures. The processer motor is rated at 0/250 h.p. at 1000 r.p.m. maximum, and that for the roller leveller at 0/225 h.p. at 1150 r.p.m. maximum, while the six machines driving the tables and pinch rolls total approximately 180 h.p.

The operation of the complete line is controlled from console desks at the entry section, the up-cut shear and the finishing section. The control desk for the shear (illustrated above), is of stainless steel and the centre section embodies a total of thirty-four control switches which are arranged, together with the necessary indicating instruments in two manuals. As the overall width of the new switch is only 1⅛in, all the controls for the section are located within easy reach of the operator's hands. Further advantages of these switches are that the contact arrangement can readily be adapted to suit all normal control requirements, and that the complete switch mechanism can be quickly unplugged from its housing for inspection and maintenance. These control switches were designed in collaboration with the consultants. The cabinets at the ends of the desk accommodate the indicator lamps, emergency stop push button and the regulators and potentiometers associated with the control scheme. The shear control desk forms the principal control centre for the complete line ; the desks for the entry and finishing sections are similar to the shear desk, but the number of circuits controlled from them is smaller.



Drives for entry section of the cut-up line. The 40kW drag generator can be seen (right foreground) and mounted above it is the 250 h.p. motor for the processer

The entry and delivery sections of the line are separately controlled, and each is equipped with its own generator and associated control exciter. The exciters are basically voltage controlled, though a current-limiting device is incorporated to prevent excessive acceleration and retardation of the line. The two main generators are identical, but the maximum voltage of the entry section generator is limited to 400V, while the output of the delivery section generator at full speed is 500V. This voltage difference enables the delivery section to run faster than the entry section, and so clear the cut lengths from the shear. Regulators for controlling both the crawl and running speeds of the line are on each desk.

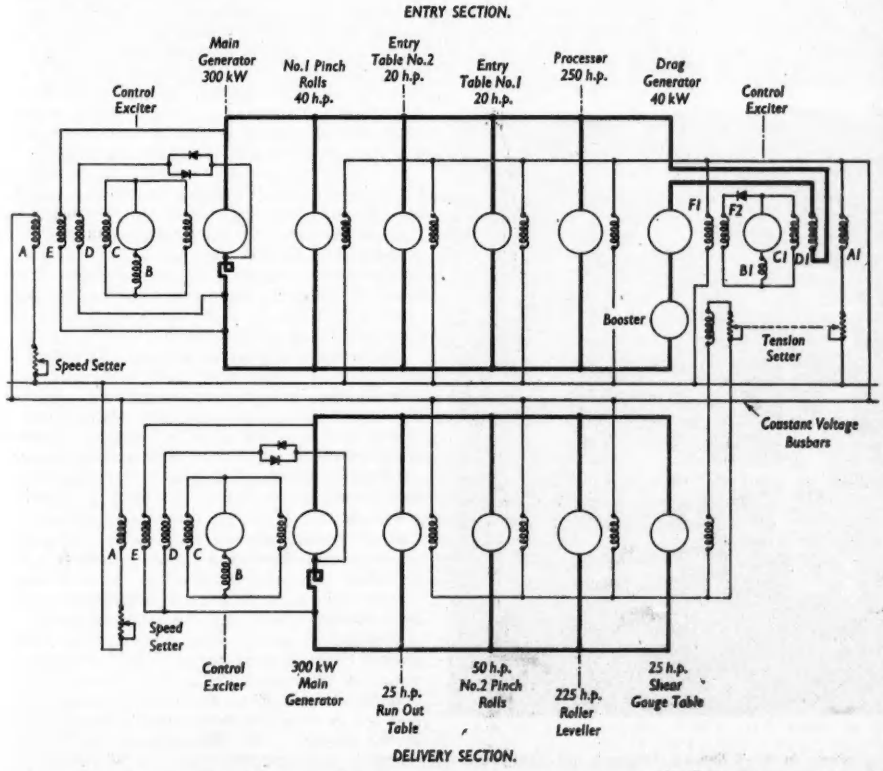
As shown in the schematic diagram, the control exciters for the main generators are each equipped with five field windings, of which *A* and *B* are positive fields which tend to increase the voltage output of the exciter, and *C*, *D* and *E* are negative fields which oppose *A* and *B*. Field *A* is the voltage setting field which enables the speed of the section to be controlled from the regulator on the control desk. *B* and *C* are stabilising windings, *D* is the current limit field which is connected in series with a metal rectifier across the interpoles of the main generator, and *E* is the voltage resetting field which is connected across the main generator.

A voltage proportional to the desired speed of the section is fed to the field *A*. The voltage output of the control exciter and, hence, of the main generator, builds up until the voltage across field *E* nearly equals that across field *A*, the slight difference being sufficient to keep the main generator excited at the desired voltage. If the voltage fed to field *A* is reduced, field *E* will predominate and the voltage output of the exciter will be reduced until fields *E* and *A* are again almost in balance. If field *A* is reduced to zero, regenerative braking will be applied to stop the section. During acceleration or retardation, any increase in current above the set value of twice full load will cause the current-limit rectifiers associated with field *D* to become conductive. The resultant current in *D* tends to reduce the main generator voltage during acceleration and to increase the voltage during retardation, thus limiting the load current to the set value.

The stabilising field *B* is connected in series with the main generator field, while field *C* is connected across the armature of the exciter. Under normal conditions the effects of the two windings are almost equal and opposite, but during rapid changes *B* will lag behind *C* because of the inductance of the main generator field. Field *C*, acting as a source of negative feedback, will then cause the output voltage of the exciter to fall, thus preventing hunting. In practice, field *B* is made slightly more powerful than field *C*, and acts as a self-sustaining series field for the exciter, so that a small difference between the setting and resetting fields will produce full output from the exciter, thus increasing the accuracy of the system.

The drag generator is used to maintain constant tension in the strip during its passage through the entry section. The generator has two field windings, *F*1 and *F*2, of which *F*1 is excited from the constant voltage busbars and is set to give an empty reel speed slightly slower than the entry section. The second field, *F*2, is energised from the control exciter via a blocking rectifier which ensures that field *F*2 can only assist field *F*1. In series with the drag generator is a booster which is excited from the constant voltage busbars via a regulator ganged to the tension setter. This regulator is graded so that the booster produces a voltage proportional to the *IR* drop in the circuit. The booster is necessary to ensure effective control at very slow speeds, and is also used for inching the drag generator and for providing stalled tension when the line is stopped.

The control exciter for the drag generator has four field windings *A*1, *B*1, *C*1 and *D*1, of which *A*1 and *B*1 are positive fields which tend to increase the voltage output, and *C*1 and *D*1 are negative fields which reduce the output. Field *A*1 is the tension setting field which is excited from the constant-voltage busbars in proportion to the desired tension, and causes full field to be applied to the drag generator. As the coil of strip on the pay-off reel is unwound, the speed of the drag generator will increase in proportion with the decreasing coil diameter, and in consequence the back e.m.f. will rise, causing the feedback current to increase. The current resetting field *D*1, which is in series with the main drag generator circuit, will then oppose field *A*1 and so reduce the drag generator field and, consequently, the back e.m.f. This process will continue all the time strip is being taken off the reel, field *D*1 being slightly greater than field *A*1 to maintain the set tension. To prevent a loop from being thrown during retardation, the tension is increased to provide a component of current proportional to the braking torque.



Schematic diagram for electrical drive of cold cut-up line

Fields *B*1 and *C*1 of the control exciter are stabilising fields, *B*1 being connected in series with the controlled field and *C*1 across the armature of the control exciter. These windings act similarly to fields *B* and *C* of the exciters for the main generators, as described above.

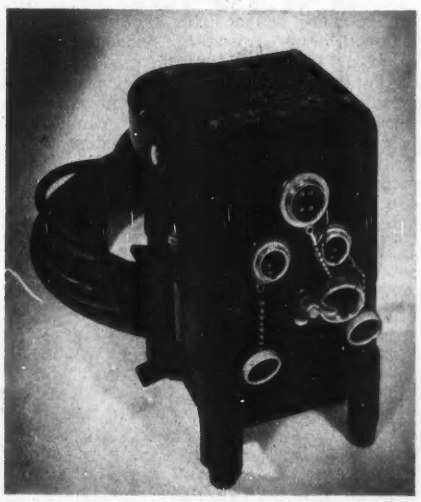
When the line is working under manual control, the various sections are under the individual control of operators seated at the three control desks, and interlocks are provided to ensure that there can be no change to automatic control while the line is running. Dual controls are provided for inching the mandrel and processer, and a changeover relay on the master control desk at the shear enables the control to be transferred from the shear desk to the entry desk. When automatic control is selected, the starting and stopping sequences are initiated by limit switches actuated either by a cut length or by the leading edge of the advancing strip.

Interlocks, relays and protective devices are installed to prevent the line from being started until the shear motor and all a.c. auxiliary drives, such as oil pumps, hydraulic pumps, and fans, are in operation, and to prevent damage should the various controls be operated in an incorrect sequence. In addition, overload and field-failure protection has been provided for all the driving motors, while the generators are equipped with both time-delay and instant-trip overload and over-voltage protection.

Small Portable Power Transformers

CONSIDERABLE savings in weight, which should appeal to industrial users of portable tools, are claimed for a new range of transformers made by the transformer division of Ferranti, Ltd., Ferry Road, Edinburgh, 5.

The construction can be seen from the accompanying illustration of a 750VA equipment. The winding, which is completely enveloped in a capsule of epoxy resin, is on a C-core of cold-rolled grain-oriented silicon steel, clamped externally. An aluminium alloy casing encloses



750VA portable power transformer weighing about 24 lb. It has a C-core of cold-rolled, grain-oriented steel and the winding is encapsulated in epoxy resin

the whole assembly. Electrical protection is given by replaceable cartridge fuses which are fitted inside a cover and are rated for the full load secondary output.

Electrical Specification of 750VA Transformer

Primary winding	230/240V, 50 c/s, with earth screen between primary and secondary.
Secondary winding, 1	115V centre tapped 750VA.
Secondary winding, 2	24V, 50VA.
Temperature rise	53 deg. Cent.
Power loss	10W maximum.
Voltage regulation	6·5 per cent, maximum.
Efficiency	95 per cent.

The ratings and approximate weights of the range of transformers are as follows: 50VA, 12 lb; 300VA, 15 lb; 500VA, 18 lb; and 750VA, 24 lb. The electrical characteristics of the range are typified by the details tabulated above, of the largest transformer in the range.

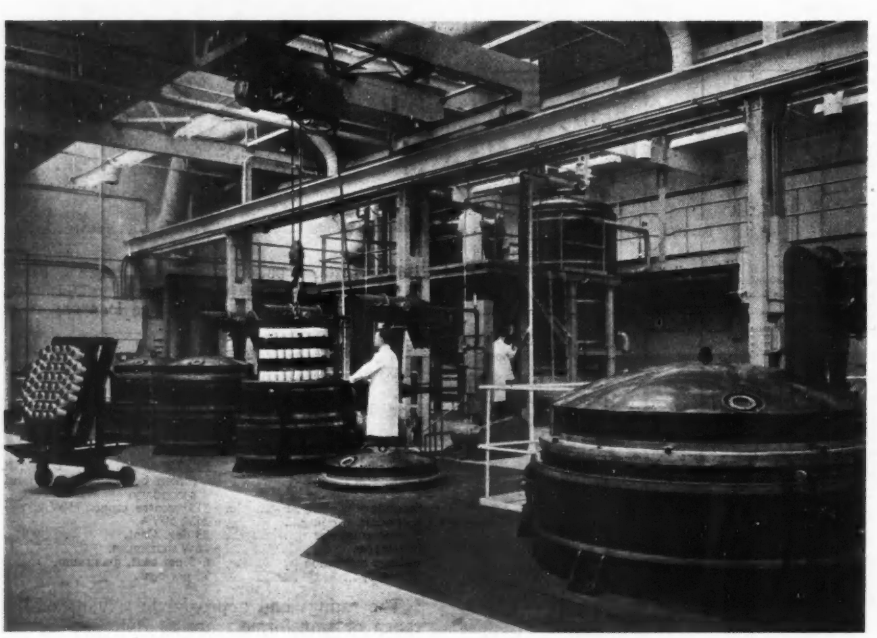
Manufacture of Power Capacitors

A new factory for the manufacture and testing of power capacitors has been built and equipped at the Elizabeth Works, New Cross, of Johnson and Phillips, Ltd. Here up-to-date vacuum engineering techniques are used for drying and impregnating the capacitor elements and special precautions are taken to maintain cleanliness during manufacture. The air in the winding room illustrated here is doubly filtered and conditioned. The processing shop in which the elements are vacuum dried, impregnated, tested and tanked is also air conditioned. An outline of the manufacture is given below.

TO meet the growing demand for capacitors for power factor improvement (a demand which is likely to be enhanced by the investment allowances for fuel saving equipment, recently announced by the Chancellor of the Exchequer), Johnson and Phillips, Ltd., has recently built a capacitor factory at the company's Elizabeth Works, New Cross. The space previously devoted to capacitor manufacture at the Victoria Works, Charlton, is being relinquished and will release space for expansion of the company's cable factory.

The new plant at the Elizabeth Works has been specially designed for the quality production of power capacitors. Modern vacuum engineering techniques are being used for drying and impregnating the capacitor elements, and precautions are taken to ensure cleanliness at all stages of production. The need for manufacturing refinements of this kind can be deduced from work which is being done, for example, by the Electrical Research Association (E.R.A.). The Association's research programme includes studies of the mechanism of inception of discharges in oil-impregnated paper initially free from voids. On this subject the current annual report of the E.R.A. says " . . . the main factor controlling the inception of stress is now known to be the moisture content, although the mechanism through which this factor operates is not yet understood. This work has emphasised the need already apparent for many years of an intensive study of the mechanism by which small quantities of ionic impurities, such as moisture, produce such disproportionately deleterious effects on the electrical properties of insulation."

These considerations emphasise the importance (confirmed by the practical experience of capacitor manufacturers) of the drying of the paper dielectric and the impregnating oil. It is equally important to avoid possible sources of contamination, particularly during the winding of the capacitor elements, for any traces of dust trapped between the layers of tissue and any contamination from perspiration reduce the life of the capacitor. The resulting manufacturing requirements are more exacting for capacitors than for other equipment using paper dielectrics, because with capacitors the dielectric must operate at a high electrical stress if an economic kVAr output is to be obtained from a given bulk of material and because of the large area of dielectric which is constantly stressed.



The main process shop for the manufacture of capacitors in the Elizabeth Works is air conditioned. Here the capacitor elements are dried and impregnated in oil under vacuum

The new capacitor factory at the Elizabeth Works is designed to meet these stringent requirements. A fully air-conditioned room houses the machines on which the capacitor elements are wound with sandwiched layers of aluminium foil and paper tissue. The air is doubly filtered to remove dust and other particles and is then warmed or cooled, according to season, under thermostatic control to maintain a constant temperature of about 68 deg. Fah. The pressure in the room is kept slightly above atmospheric and the outflow of air tends to reduce dust. The walls are smooth-enamelled and the floors of polished hardwood.

An impression of part of the winding room is given in our first illustration. Typically the aluminium foil is 6 microns thick and the paper tissues 10, 12½ or 15 microns thick. Special care is required in handling the spools of metal foil, since if the edges were damaged the feed of the material on the machine would be impaired. Accordingly the spool of foil and the wound elements are stored on racks having spindles with projecting bosses to protect the edges.

On the winding machines which can be seen in the foreground of our illustration the tensions on the spools of foil and tissue are controlled by friction clutches. On the larger machines in the background tension control is by weighted friction bends operating on the periphery of the spooled material. Terminal tags for the connection of a fuse to each capacitor element are fitted ing the winding room.

The remaining processes of vacuum drying and impregnating, preliminary testing and tanking are carried out in the processing shop. In the winding shop, as in the processing shop, the air is filtered and conditioned. The capacitor elements are dried under vacuum to remove moisture and gas before the paper dielectric is impregnated and the vacuum is not broken until the impregnation is complete.

Four vacuum impregnating vessels can be seen in our second illustration ; one of the vessels has its cover removed for loading or unloading. Rough vacuum is obtained in each sealed vessel by a Kinney pump and the final evacuation is completed by an Edwards " Speedivac " pump backed by the Kinney pump. The " Speedivac " pump is connected by a T-junction in 12in diameter trunking to the impregnating vessel, and can be seen just to the right of the operator in the centre of the illustration. The Kinney pump is connected to the 12in trunking by a smaller diameter pipe. Electro-pneumatic valves

allow the "Speedivac" pump to be by-passed during the initial pumping, and the two pumps to be connected in series for the final evacuation. The complete drying and impregnating cycle may take about four days.

During this cycle the processing vessels are heated by hot water circulating under pressure in a jacket. To maintain uniform processing conditions the temperature of the walls of the vessel is kept thermostatically at a preset value. Control is effected by a temperature-sensitive servo system which uses compressed air to operate the valves controlling the hot water flow. This system is stated to give stable operation to within ±1 deg. Cent. of the preset value.

Each processing vessel has its own pumping equipment, and all the control equipment for the pumps, the electrically operated valves, and the protective equipment, together with the vacuum gauges, pyrometer indicators and recorder, and the automatic temperature control for the vessel jacket are housed in a cubicle immediately behind each vessel and its pumps. Automatic protective equipment is provided on all the pumping equipment, and in the event of failure of the electricity supply or the cooling water for the pumps, the pumps are shut down and the processing vessel isolated and sealed so that the vacuum is maintained. Thus there is no danger of damage to the capacitors which are being processed.

When breaking the vacuum for unloading only air dried to a very low dew point is allowed to enter the processing vessels; contamination of the capacitor elements by atmospheric moisture is thus avoided.

The impregnating oil is received in bulk from road tankers. It is stored, for settling, in the first of two cylindrical tanks and is pumped through filters to the second tank, as required. A new delivery is taken only when the first tank is empty, an arrangement which allows acceptance tests to be carried out on each delivery. Oil from the second storage tank is pumped through filters to a primary and secondary dehydrating and degassing plant, under vacuum, in the processing shop. The primary and secondary cylinders can be seen in the background of the illustration. The primary cylinder, on the right, is equipped with a Kinney pump and the secondary cylinder has an Edwards "Speedivac" pump (mounted on the platform) backed by a Kinney pump installed at floor level. From the secondary cylinder the oil can be fed by gravity, under vacuum, to each of the capacitor processing vessels as required.

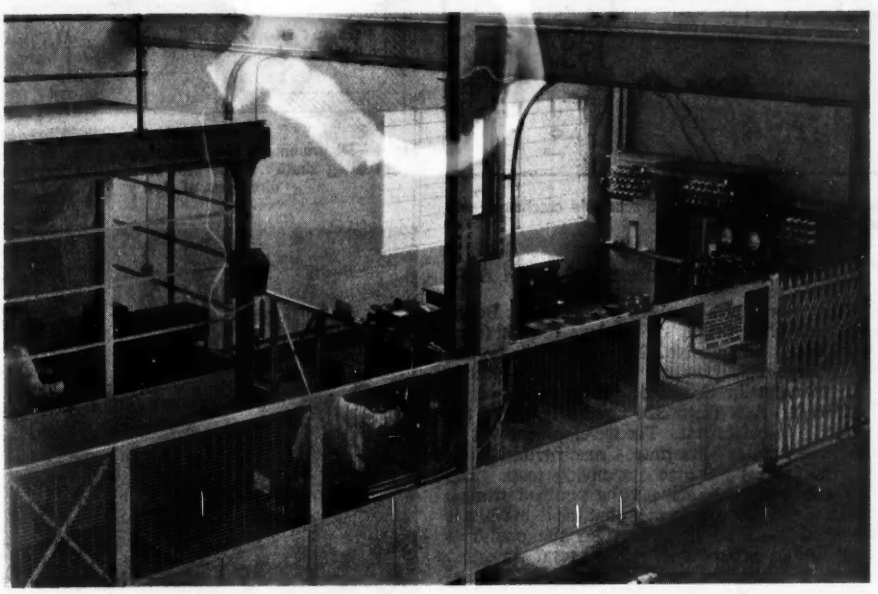
After impregnation the elements are flash tested and assembled in their frames in the conditioned atmosphere of the processing shop and are then tanked. At this stage the capacitor is basically complete apart from switchgear fittings; it is given final vacuum treatment and sealed.

Before entering the processing shop the tanks are cleaned and shot blasted and the inside surfaces are varnished in the general shop before being passed to the processing shop. At the same time all tanks designed for outdoor service are metal sprayed with aluminium before being painted. Here the various sub-assemblies are also prepared and then pre-dried in an electrically heated oven before being passed to the processing shop. At the other end of the general shop the sealed capacitors are delivered from the processing shop for the fitting of auxiliary equipment such as cable boxes, oil circuit breakers and air-break contactors, and for final painting.

Testing begins with the examination of samples of oil, on delivery, in a small laboratory adjoining the dehydrating plant. Further tests, including breakdown strength and power factor, are done before the oil enters the processing vessels. Frequent control is maintained on the composition and thickness of the paper tissue and metal foil.

After processing each element is flash tested and after assembly each capacitor undergoes a full series of tests (in accordance with B.S. 1650) in a test bay in the processing shop. A specially arranged Schering bridge enables the total losses in a complete capacitor to be measured under actual operating conditions at rated voltage. As shown in the final illustration, there is a further test bay in the general shop, for the final testing and inspecting of the complete equipment together with its control gear when fitted. An interesting method of fault detection is used here. A microphone is clamped to the tank and is connected to an amplifier and loud-speaker in the adjoining instrument room. Incipient faults can thus be picked up by microphony with the capacitor on full voltage.

The whole capacitor plant has been designed and installed under the direction of Mr. F. Moores, B.Sc. (Eng.), M.I.E.E., manager of the J. and P. capacitor department. The processing plant was manufactured by Edwards High Vacuum, Ltd., and the air conditioning plant by the Sturtevant Engineering Company, Ltd.



A batch of capacitors in the main test bay. A Schering bridge can be seen in the instrument room on the left. The test area is enclosed by electrically interlocked screens

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PURE BORON.—Crystalline elemental boron, claimed to be 99 to 99·7 per cent pure, is being marketed by Borax Consolidated, Ltd., Borax House, Carlisle Place, London, S.W.1. It is stated by the maker that the new product is far more inert than the finely divided amorphous material, and that the low oxygen and nitrogen contents favour use in alloys.

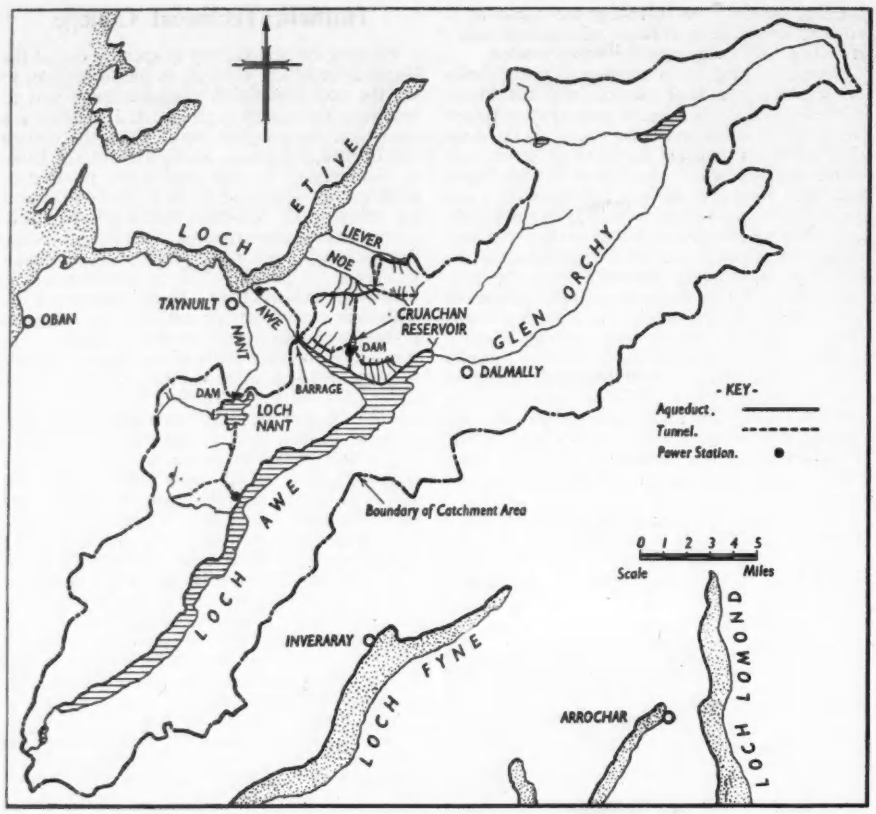
Hatfield Technical College

WE were invited recently to spend a day at the Hatfield Technical College, in Hertfordshire, to see the accommodation provided there and to hear from the principal, Dr. W. A. J. Chapman, a report on the progress made since the college was opened, five years ago, by H.R.H. the Duke of Edinburgh. In that period the number of students has increased from 1738 to 3922 and the number of full-time teaching staff from thirty-three to seventy-seven. When the college was planned there were certain factors which influenced the project. The development of the new towns at Hatfield and Welwyn Garden City, with their accompanying industrial growth, was proceeding, and there were known increases of population in other parts of the county. Some firms, which had hitherto made other arrangements for further education, expressed their interest in and readiness to support the new college. In fact, the main impetus to the growth of the college has been the interest shown by industry. It is readily acknowledged that the specialised work of the various departments could, in many cases, be met only by engaging visiting teachers from industry. These teachers have taken a large share of the evening work, and firms have also co-operated with the college by permitting their key men to assist in the daytime instruction. This close contact with industry was emphasised by the principal in his report because, he said, perhaps above all other things it had contributed to the growth and confidence in the work of the college.

The work of the college is carried on in six main departments, namely, aeronautical and mechanical design; mechanical and production engineering; electrical engineering; science; building; commerce, social and professional studies. In the first of these departments, instruction is provided to high levels in the main branches of mechanical, aeronautical and civil engineering. Since the opening of the college, the National Certificate courses have become well established, generally following the national pattern, though there is provision for specialisation in aeronautical engineering. Two years ago part-time courses were started in preparation for the B.Sc. (Eng.) degree of London University; the first group of students will sit for their finals at the end of the 1958–59 session. In the department of mechanical and production engineering there are now 1500 students, even though some of the second-year work has been passed to the Colleges of Further Education in the neighbourhood. During the present session, the department has been running a post-graduate course in production engineering. In the college's first year a "four-term system" was introduced by the department of mechanical and production engineering which permitted members of the staff to spend periods in diverse industries and educational establishments. This enabled investigations into student, employer and college relationships to be made, and new production methods in various factories throughout the country to be studied.

The department of electrical engineering was established as a separate entity in April, 1956; up till that time instruction in electrical engineering had been part of the activity of the aeronautical and mechanical design department. With the present emphasis on electronics, automation and guided weapons, the electrical department is receiving an increasing number of students; its syllabus now includes courses in advanced electronics, servo mechanisms, analogue computers and transistors. In addition to sandwich diploma courses and national certificate courses, the department is now running a degree course in electrical engineering. The expectation is that by 1960 the electrical engineering department will concentrate wholly on diploma, degree, higher National certificate and post-graduate specialist courses.

The department of science has been functioning as a separate unit since the beginning of 1953. A recent development is that a visiting committee of the Royal Institute of Chemistry has recommended that the college should be accorded recognition for the training of students to Parts I and II of the Institute's graduate examination. Recent developments in the department of building include a higher national certificate course



The principal constructional works of the Awe scheme are shown in this map of the scheme's catchment and the surrounding area

in civil engineering, and the introduction of specialist evening courses in town planning, building inspection and concrete practice.

The importance of introducing a liberal element into technical education is emphasised by the work of the commerce, social and professional studies department at Hatfield. The social studies include economics, practical science, sociology, literature and geography. On the occasion of our recent visit to the college, we were told that the Hertfordshire education authority has been active, for some years, in encouraging the liberalisation of technical education. The function of "social studies," it is generally accepted, is to supply a social background to technical studies and a balance between technology and the humanities. There is a need for the correlation of engineering and science studies on the one hand and of the study of man and society on the other. But how that can be achieved in practice is not always obvious. A couple of years ago, it was thought desirable to bring together those teachers in Hertfordshire who had had considerable experience in social studies for full-time, sandwich course and day-release students. This "social studies conference" was held at the Hatfield Technical College and, as a result of it, a permanent social studies committee for the county was formed. The principal terms of reference of the committee are: to consider common syllabuses for social studies, with a view to co-ordinating work done at the colleges of further education with that done at the technical colleges; to consider the possibility of a central information service, and to formulate a statement of the purpose and aims of social studies. The "common syllabuses" have now been planned, and the committee is agreed that the main purpose of a social studies course is to help students to acquire an imaginative interest in, and to form an unprejudiced judgment on, those matters which concern their lives and that of the community. This, it is urged, may be achieved through an understanding of man in relation to his environment, of his civic and social institutions, relationships and responsibilities, and an appreciation of literature and the arts. The work of the social studies department at Hatfield, and the work of the other departments also, is greatly assisted by the well-arranged college library.

Pumped Storage Scheme at Loch Awe

THE North of Scotland Hydro-Electric Board has published details of its Awe project (constructional scheme No. 28), which will be the first large-scale pumped storage hydro-electric development in Scotland. It is proposed to utilise the flow from 324 square miles of the River Awe catchment. The development will be in three sections—Inverawe, Cruachan and Nant, as indicated by the accompanying map. The Cruachan section includes the pumped storage works, and we are informed that the date when it proceeds will be dependent on the country's generating programme. The total installed capacity of the scheme will be about 450MW and the estimated cost £24,500,000.

The Inverawe section, which is a straightforward development of the water power of the River Awe, involves regulation of Loch Awe by a low barrage a short distance downstream from the outlet of the loch. It is not intended to raise the level of the loch. From the barrage water would be taken by a tunnel to a power station situated just within the mouth of the river. The station would have an installed capacity of about 35MW and an average annual output of 101 million kWh. Release of compensation water into the River Awe from the barrage and the construction of a fish pass there are both envisaged.

The Cruachan section includes the pumped storage plant and therefore will have the large capacity of about 400MW. When the system load is low, water from Loch Awe will be pumped to a high-level reservoir, formed in the corrie on Ben Cruachan at the head of the Cruachan Burn at a height of about 1300ft. The reservoir will be connected by shafts to the plant in an underground power station and the water used will be conveyed to and from Loch Awe by a horizontal tunnel. The combined pumping and generating machines will be fed mainly by water pumped from Loch Awe, supplemented by water collected by aqueducts from the headwaters of the Rivers Liever and Noe.

The Nant section of the scheme will involve the raising of the level of Loch Nant by the construction of a dam near its outlet. A tunnel and pipeline will lead from the reservoir to the power station near Inverinan, on the shore of Loch Awe. The station will have a capacity of 18MW and an annual estimated output of 27 million kWh. Compensation water will be released to the River Nant during dry periods.

Spring Metallic Seals for Hot Gases

THE leaf-spring principle of sealing is reported to have been giving satisfactory service in water-tube boiler installations for a number of years. The principle can be employed in a number of ways, and it is at present being considered for adoption in projected nuclear power stations. The maker cites uses on Lancashire and Economic boilers, and describes applications to draught controls, isolating dampers for boiler outlets, by-pass flue dampers, mine ventilating shafts and metallurgical furnaces.

One application of the principle is shown in Fig. 1. Sealing elements of this kind are used along the sides of the Monel metal roller curtain illustrated in Fig. 2. The unit shown is now

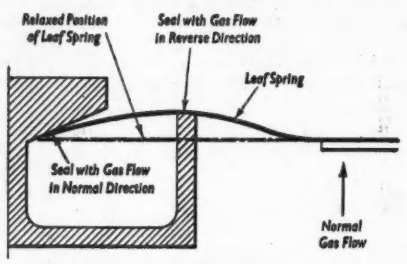

Relaxed Position of Leaf Spring
Seal with Gas Flow in Reverse Direction
Leaf Spring
Seal with Gas Flow in Normal Direction
Normal Gas Flow

Fig. 1—Diagrammatic view of leaf spring seal in gas-tight sealing shutter. The seal is effective for both directions of flow

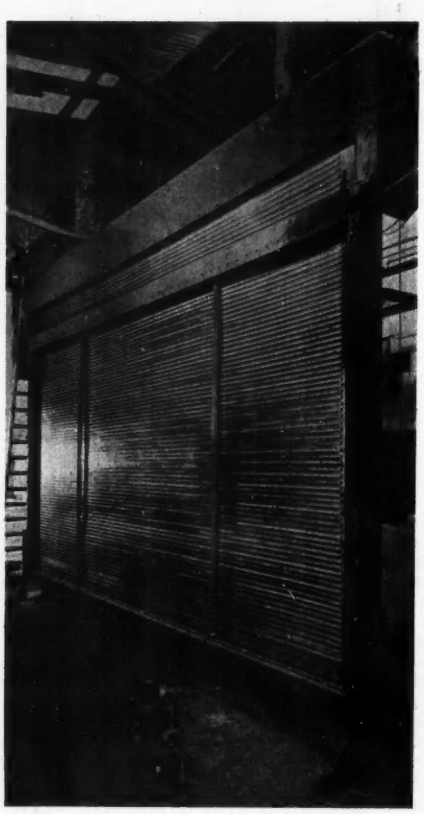


Fig. 2—An all-metal, gas-tight sealing curtain, 16ft by 8ft, now being delivered for installation on the boiler outlet flues at Little Barford "B" Power Station, C.E.A., Eastern Division

being delivered for installation on the 16ft by 8ft 6in outlet flues of one of the new boilers at Little Barford "B" power station, C.E.A. Eastern Division.

The virtue claimed for the leaf-spring seal is that it will cut down leakage in large ducts and flues even though there may be distortion and

misalignment in surrounding structure.

Relative lightness of structure often leads to increased distortion as a result of high temperature, and a form of seal that can accommodate itself to changes in local geometry is obviously desirable. In this country, which depends mainly on fuels for its energy, about half of the generating capacity works an eight-hour shift per day, and some of the remainder work two shifts a day. Gas-tight sealing of flues secures economy by avoiding fuel consumption during periodic shut-downs (otherwise necessary to prevent cooling). Good sealing can also eliminate fatigue caused by repeated heating and cooling of boiler parts, reduce attack by acid condensate, and prevent flow-back of gases from the main flues into the boiler during stand-by periods. Thus additional economy results from reduced outage ; the cost of the latter has doubled or trebled since the last war.

The leaf springs themselves are of specially rolled temperature-resistant austenitic steel, five to fifteen-thousandths of an inch in thickness. They are said to cockle very little, even after long service, and their effectiveness is not affected by whatever cockling does occur. Temperatures up to 1000 deg. Fah. can be accommodated easily and 1200 deg. Fah. is quoted as the present upper limit.

Units incorporating these sealing elements are designed to permit ready removal and replacement without seriously interrupting the operation of the main plant. This is a great advantage on equipment taking days to cool sufficiently for direct labour to become possible.

The equipment is marketed by Metropolitan Combustion Engineering, Ltd., 47, Whitechapel High Street, London, E.1.

Aluminium-Ingot Scalping Machine

AN aluminium-ingot scalping machine, claimed to be the first of its kind manufactured in this country, has been installed at the Banbury works of the Northern Aluminium Company, Ltd. The complete installation consists of the scalping machine itself, a travelling work-table, ingot loading table, scrap conveyor and crusher, and a centrifuge oil-remover. Our illustration shows the scalping machine with a ½-ton ingot held in position by two of the four hydraulic clamps. The centrifuge oil-remover is visible at the left of the picture.

In effect, the scalper is a special-purpose milling machine. The cutting head comprises thirty-two roughing tools and two finishing tools on a 5ft pitch circle diameter, and is driven by a 400 h.p. a.c. motor at 245 r.p.m. The work-table is driven by a 25 h.p. a.c. motor through a rack and pinion. The ingot crosses the cutting head at a speed from 5ft to 15ft per minute, depending on the hardness of the alloy. The depth of cut is generally about $\frac{1}{16}$in, and is controlled by a preset stylus. When one side of the ingot has been completely scalped, the cutting head is withdrawn and the table returns to the loading position at a speed of 60ft per minute.

The ingot is first placed on the hydraulically operated loading table by an electrically controlled grab. The table is provided with rollers, and it can be tilted to run the ingot toward or away from the scalper. The two parts of the table are hinged together, and are used to turn over the work-piece.

Swarf is carried from below the cutting head by a horizontal conveyor, and is delivered to a crusher at an average rate of 2 tons per hour. The reduced scrap is taken by a bucket elevator and emptied down a chute into a perforated basket. When the latter is full, it is spun in a centrifuge to separate oil from the scrap. After a few minutes the basket is lifted out, and the contents are then ready for re-melting.

Ingots up to 72in by 54in by 10in can be dealt with, and the maximum size can be scalped at a rate of ten an hour. All the controls are handled by one man : this operator can load and unload ingots alone if necessary, but an assistant is desirable. A third man looks after the oil separator and the disposal of scrap.

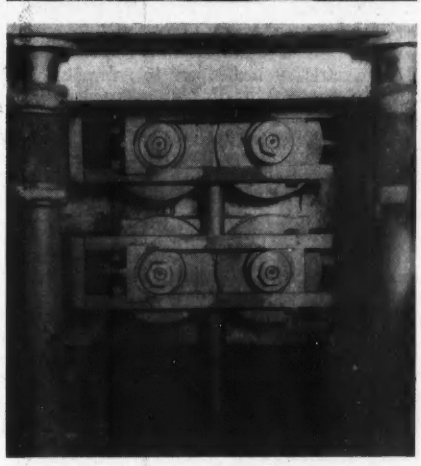
The unit at the Banbury works will eventually replace eleven small scalping machines, each of which is at present worked by one man. Full operation of the unit is expected when a new hot mill rolling 1-ton ingots is complete.

The scalper at the Banbury works of Northern Aluminium Company, Ltd. A ½-ton ingot is clamped in position (using two of the four hydraulic clamps only) and ready for scalping. The centrifuge oil remover is visible on the left-hand side of the picture

Open Days at the Tin Research Institute

OPEN days marking its twenty-fifth anniversary were held by the Tin Research Institute on July 10 and 11. The laboratories at Greenford, Middlesex, are devoted to the study of coatings of various kinds, mechanical properties, manufacturing processes, bearings, corrosion, chemical analysis, powder metallurgy, and so on. Some of the techniques used at the Institute were demonstrated to visitors.

A natural focus of attention was the continuous casting machine developed by the Institute. This makes use of a graphite mould fixed in a water jacket, and fed through a gas-heated tundish. Molten bronze is intermittently poured into the tun-dish from a manually tilted high-frequency induction furnace, and the solidified bronze strand is drawn down beneath the machine by power-driven reels (as in our illustration) or screws. The cast has a coarse macrostructure with finely dispersed microconstituents, and the surface quality is good. It was stated that machines of the same kind are in commercial use in this country. These produce bars and tubes discontinuously in the sense that the desired lengths are not cut from continuously emerging stock.



The upper illustration shows the tundish being replenished on the Tin Research Institute's continuous casting machine. The pipes supplying the water jets below the mould can be seen—they provide cooling additional to that already given by the water jacket round the mould. In the lower illustration the solid bar can be seen as it is drawn down from the mould by the four power-driven reels

Aluminium-tin alloy is bonded to steel strip in the laboratories for use in motor-car engine bearings. Two processes have been evolved for the production of the bi-metal, in both of which the Institute's 10in by 10in mill is used to roll the two strips together. In one of the processes the steel strip is given a first coat of thin foil before proceeding to the final cladding. In the other process the thin undercoat is omitted. It is necessary to make the hardnesses of the two metals approximately equal—otherwise the differential elongation in rolling shears the layers apart. A very simple peeling test has been devised for checking the bond strength.

Petrol engine and diesel engine bearings are tested in Underwood machines which simulate operating conditions. Barium titanate strain gauges are used for continuous load indication. The endurance of various materials is being investigated, and it is hoped to publish a number of results in due course.

High-temperature fatigue tests are carried out on Wohler-type machines in which the test piece is stationary and an unbalanced rotor applies the bending load. This permits the ready measurement of temperature on the surface of the specimen, the latter being mounted in a suitable heating jacket. The test load is inferred from comparison of the measured deflection with static calibration figures.

Research on corrosion forms a major part

of the Institute's activity. Tinplate is a dominant theme, with many variations. Improved techniques have been developed for coating cast iron with tin: results superior to any obtained in the past are claimed.

Methods of electrodeposition have been developed for alloys such as tin-copper, tin-zinc, tin-cadmium, and tin-nickel. Coats can be applied to steel, copper, and brass to give a brightly polished appearance.

Fungicides based on organotin compounds were shown in the laboratories. They are said to be among the most powerful known, and are being brought into use in a number of industries.

We understand that all the services and publications of the Institute are available free of charge. Handbooks for the practical user, research reports, and both general and specialised papers appear in the list of publications. In particular the Institute has just issued an illustrated booklet entitled "Tin Research, 1932–57," written by the director, Dr. E. S. Hedges. Copies will be supplied gratis on application to Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex.

Electric Die-Casting Furnace

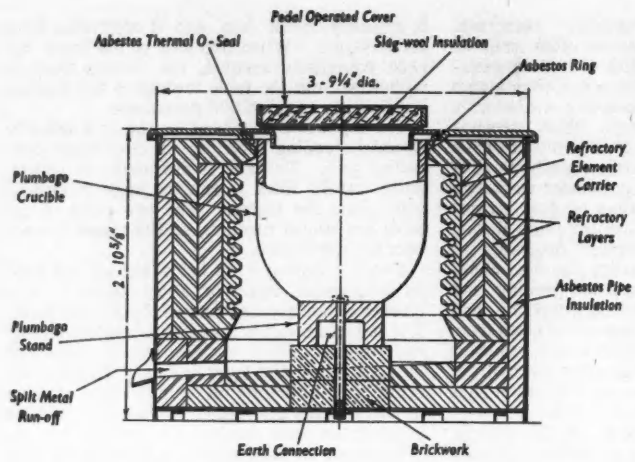
An electrically heated crucible furnace with capacity for 300 lb of aluminium has been developed in collaboration by the Morgan Crucible Company, Ltd., and Birlec, Ltd. It is intended for use as a maintaining furnace in die casting foundries. Heating is automatically controlled by an on-off regulator, and up to 800 deg. Cent. can be held within ±5 deg. Cent. A time switch can also be fitted.

The heating coils are of nickel-chrome alloy and are estimated to last one and a half to two years. A power cutout is provided to prevent the metal or element temperatures from exceeding

Depression of the pedal swings the cover clear on this 300 lb aluminium die-casting furnace. Heating is electrical and is automatically controlled from the panel shown behind the furnace

safe limits; "Chromel"-"Alumel" compensated thermocouples measure the temperatures. The triple-pole contactor is of the mercury switch variety, and the circuit breaker is ironclad, oil-immersed and manually operated, with magnetic overload and no-volt protection. The supply required is three-phase, 50 c/s., and where a fourth wire is not available an additional transformer is required on the control panel. Power input is 9kW to maintain 300 lb of aluminium at 720 deg. Cent.

The illustration above shows how the cover swings aside when the operator depresses the pedal



Arrangement of electric die-casting furnace: 300 lb aluminium capacity

bar. The accompanying section drawing shows the lining arrangements—an outer layer of insulating slabs and two inner layers of refractory brick.

The furnace is claimed by the maker to be safe and foolproof, enabling the operator to devote virtually all his attention to the business of casting.

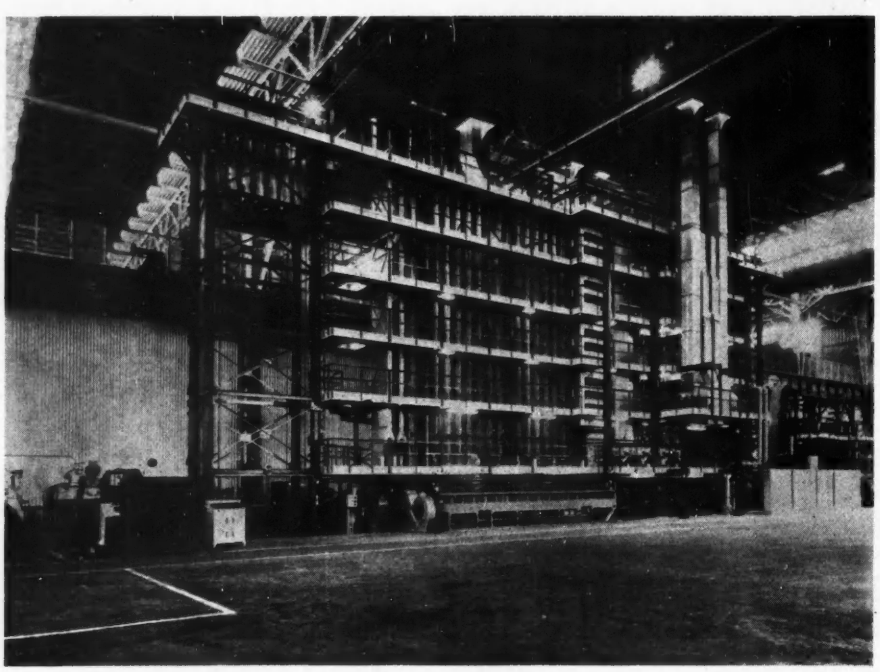
Continuous Strip Annealing Plant

A new plant for the continuous cleaning and annealing of steel strip has been started up at the Velindre Works of the Steel Company of Wales, Ltd. This plant, shown in the accompanying illustration, is the first to be installed in Europe for handling, at 600ft per minute, steel strip of the width required for tinplate production. The new continuous annealer is approximately 210ft long and 53ft high, and the total length of steel strip in the furnace and cooling zone at any one time is about half a mile. The plant can handle strip 38in wide and of normal tinplate gauges at a speed of approximately 600ft per minute, or a coil weighing some 30,000 lb every hour.

Coils received from the cold reduction mill are loaded by crane or tractor on to entry jacks at the plant. From these jacks the coils are pushed on to either of two mandrel pay-off reels, from which the strip is unwound, and since the operation is continuous the leading end of each coil is sheared and welded to the trailing end of the preceding coil. The strip then passes through a vertical alkaline cleaning section which removes all traces of rolling oil and dries the strip before it passes through the looping tower prior to entering the furnace. Looping towers at each end of the line provide a reserve, so that the strip does not have to be stopped in the furnace whilst the coils are being welded at the entry end or being taken off at the delivery end.

After cleaning the strip enters the heating section of the furnace which contains five heating passes. In this section the strip is heated by town gas to the annealing temperature of 1350 deg. Fah. in 17·4 seconds. The strip then passes into an electrically heated, two-strand soaking section, followed by three main cooling stages. In the first of these stages there are three passes of slow cooling designed to reduce the temperature to about 800 deg. Fah. by air cooling. In the second there are sixteen fast cooling passes in which water jacket cooling further reduces the temperature to around 250 deg. Fah. Two final forced air cooling passes cool the strip to approximately 150 deg. Fah.

During the heating, soaking and cooling cycle "DX" atmosphere gas is circulated inside the furnace section to prevent oxidisation of the strip. The three units for generating this gas at 6000 cubic feet per hour are located in the same building as the generators for the "H.N.X." gas used for the batch annealing installation in another part of the works. The continuous annealing plant was manufactured and installed by the Incandescent Heat Group of Smethwick as main contractors, and it was designed in collaboration with that firm's associates, the Drever Company of Pennsylvania, U.S.A. The strip handling equipment for the plant was supplied by Davy and United Engineering Company, of Sheffield.



Continuous cleaning and annealing plant for handling steel strip up to 38in wide at 600ft per minute

Industrial and Labour Notes

Iron and Steel

This week, the Iron and Steel Board has published its annual report for 1956 and a " special report " entitled *Development in the Iron and Steel Industry*. The first of these documents gives an account of the Board's activities last year as required by the Iron and Steel Act, 1953. There is, of course, a great deal of statistical material about the British iron and steel industry's operations, most of which has already been published.

There is also a chapter dealing with " Costs and Prices," in which there is a comment on price levels and the earnings of the iron and steel industry. In its price policy, the Board has recognised that expansion and modernisation must be made commercially worth while. The Board says that it has no " inflexible concepts " and that it appreciates the financial problems with which producers are faced in mounting a major programme of expansion. The extent to which expansion should be financed from retained earnings is a difficult question affecting all industry under the current circumstances of a restricted market and high levels of taxation. Whether the present price levels of iron and steel are adequate in this regard, the report adds, will continue to be the subject of close study.

Development in the Steel Industry

The special report on development in the iron and steel industry, mentioned in the preceding note, has been prepared by the Iron and Steel Board and submitted to the Minister of Power. The last such report, which was published in February, 1955, dealt with developments over the five-year period 1953–1958. The present document covers the years to the end of 1962 and also gives some consideration to later years.

In the opening paragraphs of the report it is explained that the financial responsibility for development in the iron and steel industry lies with individual producers " who in the end must plan and carry out the projects." Development is a continuous process both as regards the modernisation and expansion of capacity ; it is the subject of continuing study on the part of individual producers, their trade associations and the Iron and Steel Board. The Board's function, in consultation with all concerned, is to form a judgment about the level of demand ; to consider whether the scale and pace of development are adequate in relation thereto and whether individual projects are sound in themselves ; to ensure that the pattern of development is likely to conform with longer term conditions, and, if necessary, to persuade producers to extend or modify their plans accordingly.

A complete review of the probable level of steel demand in 1962 was completed towards the end of last year. The Board has made its estimate on the basis that industrial production will increase more rapidly in the next five years than in the past five years ; on that basis it is expected that steel requirements for home consumption will amount to 24,000,000 ingot tons by 1962. The export demand has been assessed at 5,000,000 tons. The Board has also thought it desirable to aim at some margin of capacity in excess of these requirements. Taking account of the flow of re-usable steel available for reprocessing, and a small amount of imports, it is considered that a productive capacity of 29,000,000 ingot tons should be attempted, and that there should be a reasonable assurance of supplies of 30,000,000 ingot tons if these are needed.

In the light of these estimates, the report goes on to say that development projects already approved, and some of which are now in hand, would bring crude steel capacity to about 28,000,000 tons a year by 1962. A further 1,000,000 tons is in sight, it is added, though this depends in some measure on final decisions concerning proposals made by Richard Thomas and Baldwins, Ltd. As to raw materials, the Board takes the view that pig iron and scrap supplies should be adequate with " relatively small imports." Ore requirements should be met, though the increasing competition for ore from overseas is not overlooked. The Board says that it continues to press for the maximum use of home ore consistent with adequate reserves. Home ore production, which amounted last year to 16,250,000 tons, is to be raised to 22,000,000 tons a year by 1962. The Board believes that there will be still further expansion, mainly in Oxfordshire, in the northern part of Northamptonshire and in Lincolnshire. The proved and probable reserves of ore in these districts, the report says, are estimated to give a life of at least 100 years even after taking into account the expansions in pig iron production so far approved.

As to semi-finished steel, the Board states that billet production will increase as a result of projects already approved, but it adds that " there is a clear need for further modern capacity." The report points out that the development of such capacity is bound up with the kind of ore to be used, with the modernisation of existing plant both for making billets and finished products derived therefrom, and with the growth of integration between the steelmaking and the finishing stages. Some of the proposals now being discussed include billet making plant, but, the report observes, it is clear that " additional capacity for the efficient production of billets is required." About finished steel, the Board takes the view that by 1962 in most cases supplies should be adequate. It says, however, that about sheet and tinplate there are special difficulties because a modern plant cannot operate economically unless it has a considerable load. Although big developments are taking place at the existing strip mills, the Board claims that its estimates show the need for a new continuous strip mill by about 1962. The industry, on the other hand, does not believe that this need will arise until later. The Board concedes that this opinion is tenable, but it does make the observation that, even if the mill was put in hand now, no large-scale production would be forthcoming until about 1964. The report adds that " any long delay in taking a decision to build involves risk of shortage of supplies unless the hand mills can be kept in operation or production at existing continuous mills can be still further increased." It says also that though the industry's present plans will increase plate production by 60 per cent, there is likely to be " marginal scarcity " for some years.

Finally, the report points out that the expansion and modernisation of the iron and steel industry are likely to involve an expenditure of not less than £600 million in the next five years. Even then the production capacity will still include a small proportion of obsolete plant, the replacement of which has to be considered.

Engineering Exports

A survey of the United Kingdom's overseas trade in the first six months of this year, which has been made by the Board of Trade, says that the value of exports of engineering goods exceeded £113,000,000 a month, which was £4,000,000 higher than in the comparable period of 1956. The increase was mainly in the machinery divisions. Machinery other than electric, which represents the largest division in the monthly trade accounts, rose this year by 9 per cent to £47,000,000 a month. Aircraft engines, tractors, office machinery, machine tools, rolling mill equipment and plastics and rubber working machinery were all prominent contributors to the total. The markets which showed the greatest expansion were again Western Europe and the dollar countries, though there were increased sales of machinery in the first half of this year to Australia, New Zealand and Pakistan. Exports of electric machinery and apparatus were 5½ per cent higher in the first six months of this year than last, more being sent to India and the U.S.A. Exports of telegraph and telephone equipment rose substantially, and exports of scientific instruments increased 16 per cent, compared with the first half of 1956.

The Forty-Hour Week

On Thursday of last week, a claim for a forty-hour week in the engineering industry was formally presented to the Engineering and Allied Employers' National Federation by the Confederation of Shipbuilding and Engineering Unions. A claim was also lodged for a standard rate of holiday pay of £2 a day. It will be recalled that, at the end of May, when settlement of the wage dispute was made, the unions agreed not to make another wage demand for a year. They argue that the claim for a shorter week (with no loss of pay) and the standard holiday rate does not contravene the " wages standstill " undertaking. But it has been pointed out that to meet these new demands would be equivalent to a 10 per cent rise in wage costs. Nevertheless, the employers have agreed to consider the claims and to give their decision to the union confederation in about a month's time.

Marine Nuclear Propulsion

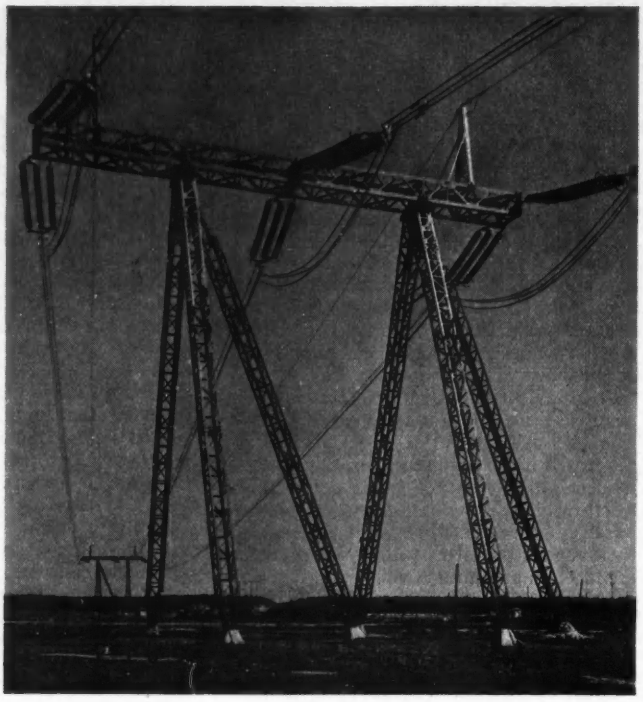
It was announced last week that the Hawker Siddeley Group, Ltd., and John Brown and Co., Ltd., are to form a new company to be known as Hawker Siddeley John Brown Nuclear Construction, Ltd., with a capital of £500,000 and the companies being equal partners. The first task of the new company will be a study of the problems of marine propulsion. The chairman of the new company, Sir Roy Dobson, thought it likely that the first nuclear-powered vessel would be an oil tanker of over 60,000 tons.

Babcock and Wilcox, Ltd., has also stated that it has been collaborating with Cammell Laird and Co. (Shipbuilders and Engineers), Ltd., in feasibility studies and development of designs of nuclear propulsion since April, 1956, and that a study has been completed for a 65,000-ton deadweight tanker using a gas-cooled graphite-moderated reactor developed from the Calder Hall unit.

Electrical Power in the U.S.S.R.

No. II—(*Continued from page 30, July 5*)

A delegation representing the British electricity supply industry visited the U.S.S.R. from April 16 to May 14, 1956. The party, consisting of nineteen members led by Lord Citrine, chairman of the Central Electricity Authority, visited a number of hydro-electric and thermal stations, including the experimental atomic power station, 80 miles from Moscow, controlled by the U.S.S.R. Academy of Sciences. The tour also included Noginsk substation, an experimental d.c. installation, a load-dispatching centre, cable-making and generating plant factories, and research institutes. Some impressions of electrical power transmission practice in Russia are given in the following résumé of part of a recently published report on the visit.



DEVELOPMENTS in electrical transmission in the U.S.S.R. are mainly concerned with schemes to establish an interconnected transmission system, in the first instance, for the country's European networks, and, later, to connect certain Siberian networks with the European networks. An outline of these systems is given in the accompanying map reproduced from our issue of May 31, 1957, page 849.

At present the main transmission voltages are 110kV, 220kV and 400kV, a.c., and it is proposed to connect Stalingrad with the Donbass by a line which will operate at 800kV, d.c., with the centre point earthed. At present, therefore, main transmission is a.c. and most of the lines operate at 110kV or 220kV. The first section of the 400kV system, consisting of one circuit of the 505-mile line between Kuybyshev and Moscow is in commission. Some design data of this line were given in our issue of June 13, 1952, page 801, and the main particulars are tabulated below.

Kuybyshev–Moscow 400kV Line

Length	505 miles.
Circuits	Two single circuits.
Sectioning	Sectioning point midway with busbars, circuit breakers and series capacitors. Two subsidiary sectioning stations at 25 per cent from each end.
Rating	1150MW with both circuits in commission, except for one circuit out of commission in one section. Stated to be only 10 per cent less than with both circuits in commission throughout. Units transmitted $6 \cdot 1 \times 10^9$kWh/annum.
Effective losses	7·5 per cent per annum of which 4½ per cent are in the line and 3 per cent in capacitors, synchronous condensers and transformers at one end.
Designed impulse strength	1500kV.
Normal span	438 yards.
Towers :	
Type	Portal.
Steel used	Elastic limit 15 tons per square inch ; breaking load 24 tons per square inch.
Design stress in steel	10 tons per square inch.
Distance between anchor towers	Average 4 miles ; maximum 6 miles.
Average weight	11·4 tons per mile.
Spacing between phases	Straight line 32·8ft ; angles 39·4ft.
Conductors :	
Material	S.C.A. steel 0·092 square inch ; aluminium 0·75 square inch ; overall diameter 1·2in.
Conductors per phase	3.
Spacing between conductors	15¾in.
Distance between spacers	65 to 75 yards (in groups of three).
Joints	Compression.
Dampers	Stockbridge type.
Normal current density	400A per square inch of Al.

For mechanical design of the transmission lines the U.S.S.R. is divided into four climatic classes and government regulations lay down loadings suitable for the climatic conditions in each region. For example, towers and conductors of the 400kV a.c. line are designed to withstand a 55 m.p.h. wind loading without any icing, but in one part of the Kuybyshev region a higher wind loading of 78 m.p.h. is specified. A minimum ground clearance of 26ft to live conductor is specified, under conditions of maximum ambient temperature and conductor current. Normally the towers are not designed to withstand broken-conductor conditions ; slipping clamps are used to reduce tower strains under such conditions.

The 400kV lines are carried on portal towers : only two standardised designs are in use, one for straight-line sites and one for heavy angle and anchor sites, as illustrated at the top of this page. Steel towers of various designs are used for 110kV double-circuit lines and for 220kV single-circuit and double-circuit lines. One design of tower in common use is of " hour-glass " profile, having a broad base, a narrow waist, and top hamper with projections carrying the two earth wires.

Common characteristics of all the steel towers in the U.S.S.R. are the use of welded joints throughout, and the absence of galvanising. Generally, sections of the towers are fabricated in the works and then erected on site by welding or bolting.

For lines up to 110kV, single-circuit, wood poles are commonly used. An interesting sidelight is the use of short poles with a " lap joint " bound with steel wire, giving the equivalent height of a single long pole. For the higher voltage lines the wooden poles are of " A " or " H " compound construction.

Overhead line insulation is by porcelain cap-and-pin assemblies, consisting of twenty-two discs on 400kV lines and fourteen discs on 220kV lines. While the Russians do not appear to use anti-fog insulators they are developing an insulator shaped rather like an hour glass which will have a long leakage path exposed to rain washing. Experimental work with conducting glaze on insulators is along similar lines to British work on this subject. As a result of recent visits to Great Britain, Russian engineers have shown considerable interest in toughened glass insulators, which are particularly attractive to them from the standpoint of maintenance. The appeal of glass insulators would lie in their possible use for new lines, rather than on existing lines, where the cost of wholesale replacement would be prohibitive.

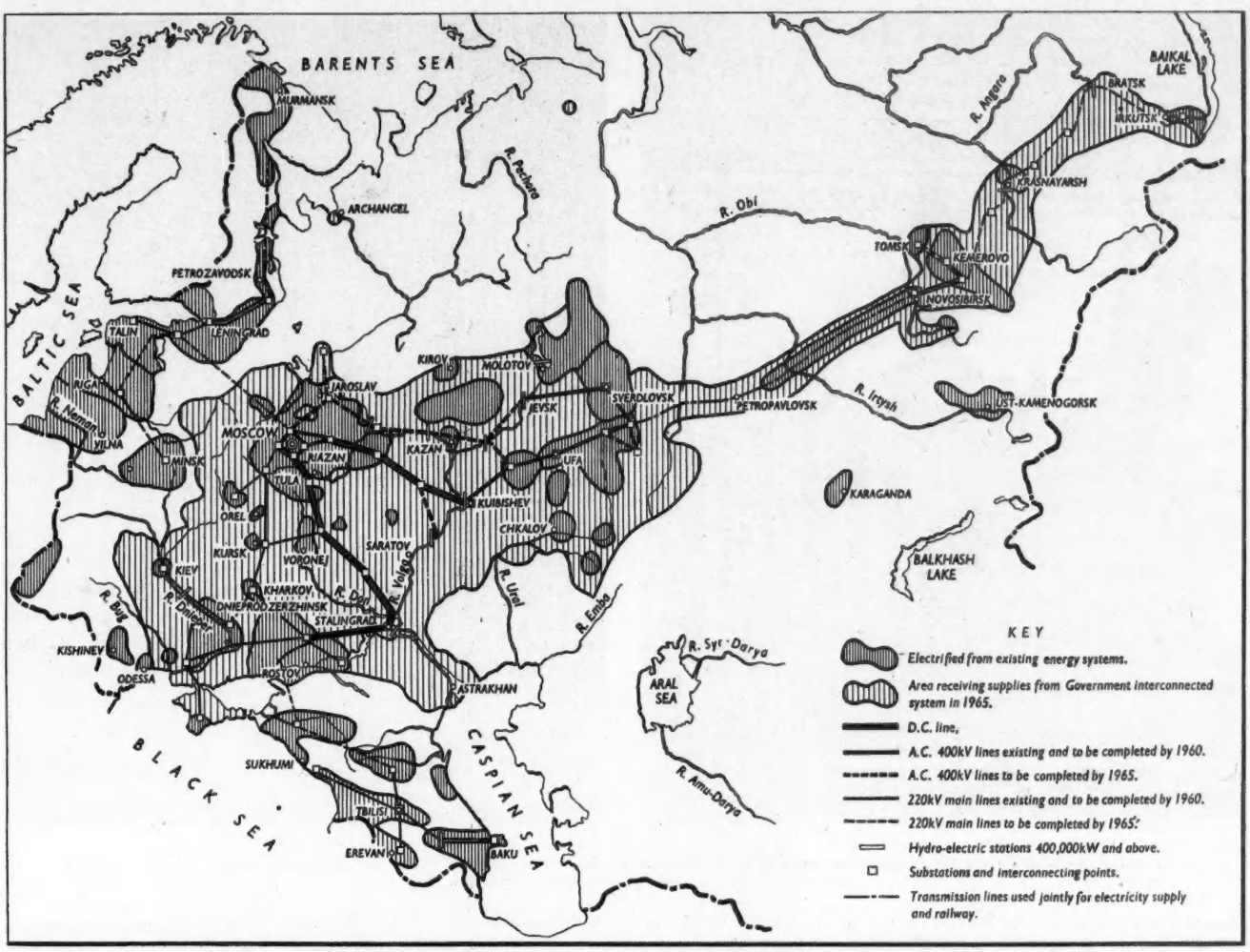
" Hot-line " maintenance is done on lines up to 220kV on circuits which are awkward to take out of service. On lines carried by wood poles " hot-line " maintenance includes the changing of cross-arms and pole members and the changing of insulators equipped with standard fittings. Fault-finding equipment, using high-frequency signals reflected from a fault on the principle of the radar echo, has been devised for use on high-voltage overhead lines, through capacitance couplers. More than 1000 of these h.f. fault-finding sets are in use.

The voltages of power cables in common use are 1kV, 3kV, 6kV, 10kV, 35kV, and 110kV, while cables for 220kV and 400kV are being manufactured on a commercial basis. A 3 mile length of 220kV cable made at the Moskabel factory was due to be in commission last year. At the Sovkabel factory, which was visited by the British delegation, it was stated that 220kV cable was being made at a rate of 9 miles per annum.

Many 650ft lengths of 400kV cable were being made for terminal connections on the Moscow-Kuybyshev system and one of these lengths was seen, during the lapping process, in the Sovkabel factory. This cable had a stranded copper core of 1·1 square inch and was lapped with 318 papers with thicknesses increasing from 0·0012in at the core to 0·0067in at the outside. The lapping machine operated in a glass enclosure presumably intended for air conditioning and temperature control. The test voltages applied to this cable were stated to be 850kV at 50 c/s and 1600kV, a.c., impulse.

Russian h.v. cable design recalls American rather than British practice in that the cable generally is enclosed in a rigid pipe, with high pressure oil. The cables are stranded solid, not hollow, and are insulated as usual with paper tapes. After applying a bronze skid wire to simplify the process of drawing into the pipe the cable is given a temporary lead sheath, which is stripped off before the cable enters the pipe. Each single-core cable is then pulled into a steel pipe which is filled with oil kept at a pressure between 45 and 205 lb per square inch. Cables for 110kV and 220kV consist of three single-core cables drawn into a single steel pipe of about 9in diameter. For 400kV service each single-core cable is drawn into a separate copper pipe. A serving of jute hessian about ¼in thick provides a protective covering and, despite the fact that no cathodic protection is applied to the pipe lines, the Russian engineers claimed that no serious corrosion had been experienced.

Typical particulars relating to a 110kV cable are : maximum stress, 100kV per centimetre ; d.c. test voltage 250kV, impulse voltage 750kV. At the time of the British visit, pressure cables using gas instead of oil were not in service in the U.S.S.R. but reference was made to experimental lengths of gas pressure cable under test.



Areas of supply and high-voltage transmission to be developed by 1965. At present there are five separately interconnected systems. The first 400kV circuit between Moscow and Kuybyshev is completed. The proposed d.c. line at ±400kV between Stalingrad and the Donbass area will be experimental

Substation Design

One of the substations visited by the British delegation was at Noginsk, near Moscow, and this installation so well exemplifies certain aspects of Russian practice that the accompanying description and illustrations may be of interest.

At Noginsk substation there are connections at 400kV, 220kV and 110kV. The 110kV part of the installation has two main busbars, each divided into two sections, and one by-pass busbar. The individual sections of the main bars are coupled by one breaker and two isolators, and the corresponding sections of the by-pass bar by one isolator only. Each 400/110kV transformer and 220/110kV transformer is provided with two 110kV breakers, one to each main busbar, with no connections to the by-pass bar. Each 110kV feeder circuit is connected to the main bars through one circuit breaker and selector isolators, but each such circuit may be connected to the by-pass bar through an isolator and through to a main bar by a common interbus breaker with selector isolators. Voltage transformers and surge diverters are connected through isolators to each main busbar section. Surge diverters are also provided on the terminal connections of each transformer.

Each of the two 270MVA, 400/110kV transformer banks is connected through an isolator direct to one of two 400kV busbars, without selection facilities. Each 400kV feeder can be connected to one or other or both busbars through two circuit breakers. Thus a transformer fault or a 400kV busbar fault would clear the corresponding transformer circuit, involving the operation of possibly three of the 400kV line circuit breakers and two 110kV transformer breakers, but without interrupting the line connections to the other transformer. The Soviet engineers told the British visitors that the risk was small in view of the rarity of transformer faults. A line fault would not affect the interconnection of other lines or the transformers.

The 400kV busbars and cross-overs are of segmental copper conductor. Rigid busbars are not used in any of the high-voltage substations. Surge diverters are connected to the transformer connections, and voltage transformers are installed on each line termination. The 220kV busbar is also connected to the 110kV busbars through two 180MVA transformers, the switchgear and ancillary arrangements being identical in plan with those on the 400kV portion.

A balanced form of protection is employed on the transformers, with a "two-float" gas-actuated relay in the pipe to the conservator to give alarm and trip in the conventional manner. For the 400kV feeders two forms of carrier protection—phase comparison and interlock—are used on the various sections between Moscow and Kuybyshev. Back-up is provided by single-zone high-speed distance protection, and reference also was made during the delegation's visit to a third provision in the form of "earth fault" protection—presumably time-delayed earth-fault protection as a final standby. Concern was expressed at the complication of all this equipment (one engineer mentioned that a total of 132 relay elements were used at one feeder end), the difficulty of maintaining and testing the electronic equipment, and the risks of incorrect operation that may be experienced. However, it was suggested that, with the provision of duplicate earth wires, low footing resistances, and surge diverters, the overhead lines should be virtually "fault-free."

The transformers at Noginsk consist of two banks of three single-phase, 90MVA, 400/110/11kV units (one of which is illustrated overleaf) and two banks of three single-phase, 60MVA, 110/220/11kV units. In all cases the transformer connections are star/star/delta.

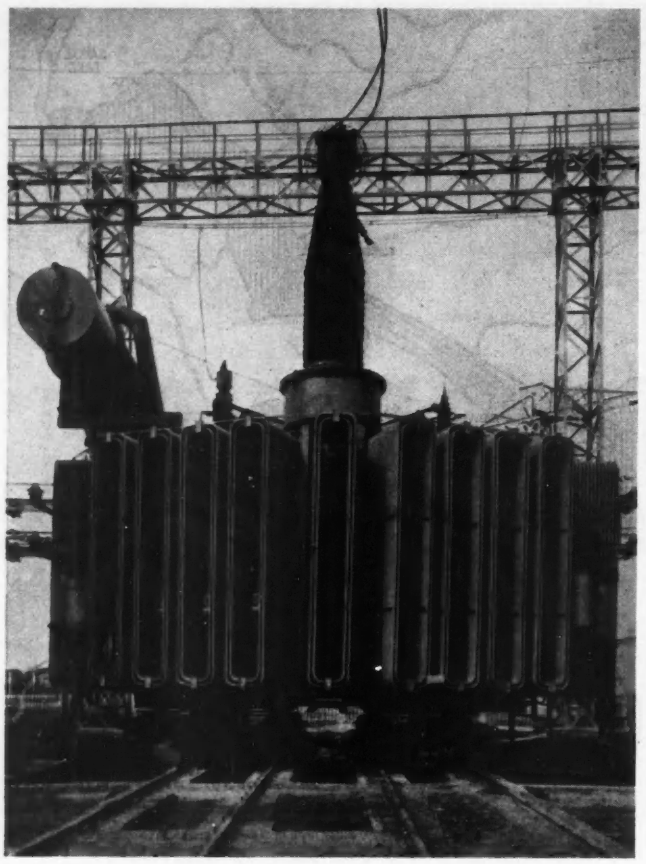
The 400kV transformers are cascade wound in three stages with parallel capacitors to equalise the voltage conditions. In fact, the transformers have four windings, namely, 400kV primary, 110kV secondary, and two 11kV tertiary windings, one of which is for a 75MVA synchronous condenser, while the other supplies excitation for the separate booster which is connected in the neutral end of the 400kV winding. The neutral-end boosters have on-load tap-changing, giving a range of ±11 per cent, and there are off-load tappings of ±5 per cent. On the 220kV transformers the delta winding is connected to a synchronous condenser.

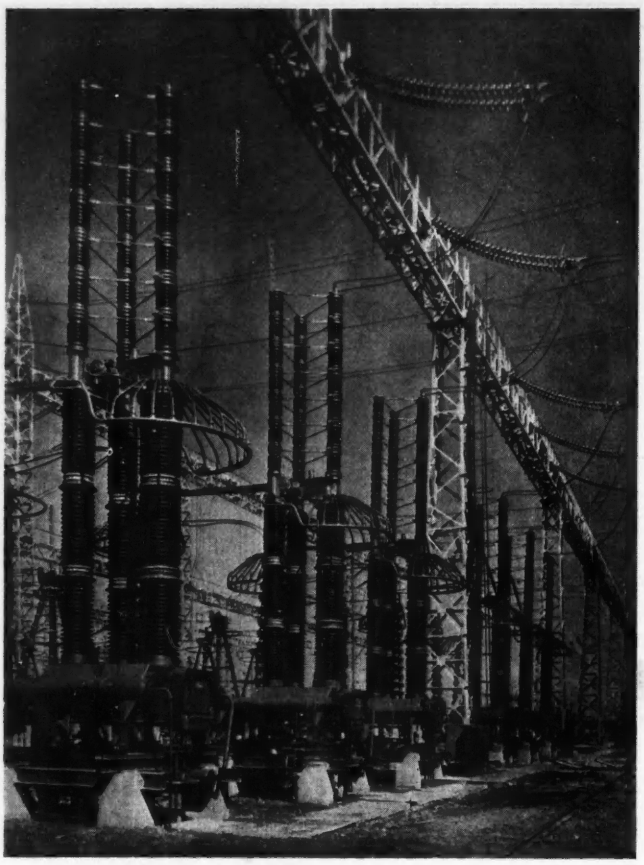
On the Noginsk site there is a large building in which the transformers are assembled and dried out. The tanks arrive outside in sections and are welded in the assembly building. The cores and windings are taken to the site in light gas-filled tanks. Finally, each single-phase transformer is moved into position on a wheeled undercarriage running on rail tracks, as can be seen in the illustration. In its final position the transformer is supported on screw jacks. A spare transformer of each rating is held on site.

All isolators in the substation are remotely operated, as are the earthing switches, and the contacts have ice-breaking properties. Above ground level all the substation structures are of welded lattice steel with earth connections of welded steel tape.

System Design

From the foregoing outline of Noginsk substation, it would appear that Russian designers of high-voltage substations are more concerned with security than with flexibility or ease of maintenance. In the 400kV substation, for example, each transformer is rigidly associated with one busbar, has no facilities for change-over, and requires that the associated transformer is out





(Left) 90MVA, 400/110/11kV single-phase transformer at Noginsk. The fans inside each cooling nest and the access tracks are of interest. (Right) 400kV air-blast switchgear at Noginsk

of service if a busbar is to be isolated for maintenance. Security is improved by the elimination of what would normally be the "busbar zone"—always a vulnerable aspect of the double-bus substation.

Supplies to Moscow and its immediate environs, amounting to over 1000MW, are given partly by local generating stations and partly by bulk supplies from outside. There is a 110kV ring, mainly overhead, interconnected with some of the local generating plant and fed at 220kV to about four points at which supplies are also stepped down to 10kV and/or 6kV. The number of these main feed points is being increased to ten in the central portion of the city, with about ten others feeding the outer districts. In one such substation visited by the delegation four incoming 110kV lines are brought into an indoor switch room containing 2500MVA air-blast breakers. Two 31·5MVA, 110/6kV transformers feed an indoor 6kV switch room containing small oil volume breakers arranged in stone cells with open-type busbars. In the Leningrad district, which has a demand of a little more than 1000MW, it appears that more use is made of an intermediate voltage of 35kV between the 110kV primary network and the 6kV distribution.

The delegation had no evidence of the use of shunt or series static capacitors in the transmission systems generally, apart from the specific installation on the Moscow-Kuybyshev 400kV system. Synchronous condensers are in use, however, at various substations on the 110kV and 220kV system normally connected to 11kV tertiary windings on the main transformers.

Direct earthing of the neutral appears to be general throughout the 110kV, 220kV and 400kV systems, but it is usual to provide a neutral isolator at 110kV neutral points so that fault current can be limited by disconnecting selected transformers from earth. At 35kV and lower voltages Petersen coils are sometimes used.

For 35kV systems it was stated that the maximum coil current is 300A and for 6kV and 10kV systems the maximum coil current is 150A to 200A. Use is made of transformer feeders at 220kV and 110kV with carrier intertrip, but teed feeders are unknown. Transformer overloading is permitted in accordance with established rules which correlate the load cycle and the ambient temperature. The net effect is somewhat similar to the British rule of 30 per cent overload in emergency (with due regard to the load cycle).

The new 400kV connection (505 miles) between Moscow and Kuybyshev, one circuit of which came into commission on a limited basis during the British visit, is initially to comprise two single circuits. One circuit will connect Kuybyshev direct to Noginsk substation south of Moscow, and one circuit will connect Kuybyshev to a new substation to the east of Moscow. An interconnector between Noginsk and the east station will permit parallel operation of the two main circuits. The design of this important connection into the Moscow system includes five main provisions. First, three intermediate switching stations arranged so that not more than one 125-mile section would be disconnected by a fault, permitting a load transfer of 1150MW in these conditions with a safety margin of 15 per cent. Secondly, high-speed automatic reclosing on the circuit breakers, single phase in all but one section which will be three-phase. Thirdly, series capacitors in the centre line sections, to compensate 52 ohms in a total of 122 ohms/circuit, i.e. 43 per cent. Fourthly, high-speed excitation on the generators at Kuybyshev, coupled with super-excitation in emergency. Fifthly, one 75MVA synchronous condenser associated with each 400kV and 220kV transformer at each receiving station.

As mentioned, one circuit to Moscow has been completed, but the second circuit, and the paralleling line at Moscow, with their intermediate substations, were still under construction at the time of the visit, and it seemed that the series condensers were not yet manufactured. However, it is expected that sufficient of the transmission system will be completed to enable full use to be made of the generators due to be commissioned this year at Kuybyshev.

It should be realised that, although the present and immediate future large transmission connections are being provided as means for transport of electrical energy from sources of power or fuel to centres of load, the value of interconnection of power sources is well appreciated and has an important part in the long-term plan. In Mr. Malenkov's speech to the Praesidium on February 17, 1956, he said "the economic advantage of inter-grid transmission lines is tremendous. It will suffice to say, for example, that since the peak load in the Ural and Central grids does not coincide and that in linking them up the required reserves can be reduced, the total installed capacity of a future combined grid could be cut by approximately 500,000kW. The establishment of a unified power grid for the European part of the U.S.S.R. will ensure maximum flexibility and saving in supplying the national economy with power. . ." In this connection it is interesting to note that the I.E.E. paper on "275kV Developments on the British Grid System," by Sayers, Forrest and Lane (1952), and the CIGRE paper on "Progress on the British 275/300kV System," by the same authors (1954), have been translated into Russian and widely circulated.

(To be concluded)

Safety Rope Attachment

A simple clamping device by means of which a workman's safety belt can be attached to the safety rope has been developed in Norway. The attachment allows the rope to be adjusted when not under tension, but immediately clamps on to it when a load is applied. It consists of a 40cm length of ¾in steel pipe with flared ends through which the safety rope passes. Near one end a window is cut into the pipe through which enters the cam-shaped end of a lever which is hinged to the pipe. On the far end of the pipe and on the other end of the lever are small pulleys over which passes the line to which the safety belt is attached. When tension is applied to this line, the pipe-lever arrangement is closed like a pair of scissors, and the eccentric cam locks the main rope against the inner pipe wall. A description may be found in EPA Digest D-1413, obtainable free from the Department of Scientific and Industrial Research, Department T.I.D.U., 15, Regent Street, London, S.W.1.

Glen Canyon Dam on the Colorado River

BY OUR AMERICAN EDITOR

One of the largest and most important contract awards of recent years in America took place in May when the Merritt-Chapman and Scott Corporation, of New York, obtained the contract from the U.S. Bureau of Reclamation for the construction of the Glen Canyon dam on the Colorado River, based on a tender of 108 million dollars. It is said that its dollar value makes this the largest single civil engineering contract ever awarded in the United States. The dam itself will be the second highest in America and will constitute a key structure of the Colorado River Storage Project. The scheme was authorised by the Congress in the spring of 1956 to develop the land and water resources of the Upper Colorado River Basin, a 10,000 square mile area containing a rich potential of agricultural, industrial, and recreational assets.

As authorised by the Congress, the Colorado River Storage Project provides for the construction of four major units and twelve participating projects. The four storage units—Glen Canyon, the Flaming Gorge dam and power station on the Green River in Utah, the Navajo dam on the San Juan River in New Mexico, and the Curecanti unit on the Gunnison River in Colorado—will provide about 34,500,000 acre-feet of reservoir capacity. The Glen Canyon and Flaming Gorge power plants will have an installed generating capacity of about 1000MW. Of the twelve participating projects, which include the existing Eden project in Wyoming, four are in Wyoming, two in Utah, one in New Mexico, and five in Colorado. These participating projects will supply water to irrigate more than 130,000 acres of presently dry land and supplemental water to about 230,000 acres of land now irrigated.

The development of the Upper Colorado River basin, through the basic storage project and participating projects, will also make possible the development of the upper basin resources of fuel, oil, minerals, and timber. It will also meet the urgent need for water to supply municipalities. Other benefits will be obtained in the upper basin from recreation, flood control, and fish and wildlife conservation, and in the lower basin from sediment retention and river regulation for power production and flood control. Virtually all of the costs of constructing and developing the four-dam storage project and the participating projects are recoverable. The power revenues will be used to repay the costs of construction, which are beyond the ability of the water users to carry. Interest will be paid on costs allocated to power and to municipal water, including interest during construction. Irrigation revenues from the participating projects will pay the operation, maintenance and replacement costs of those projects allocated to irrigation, and, in addition, will repay a part of the capital cost.

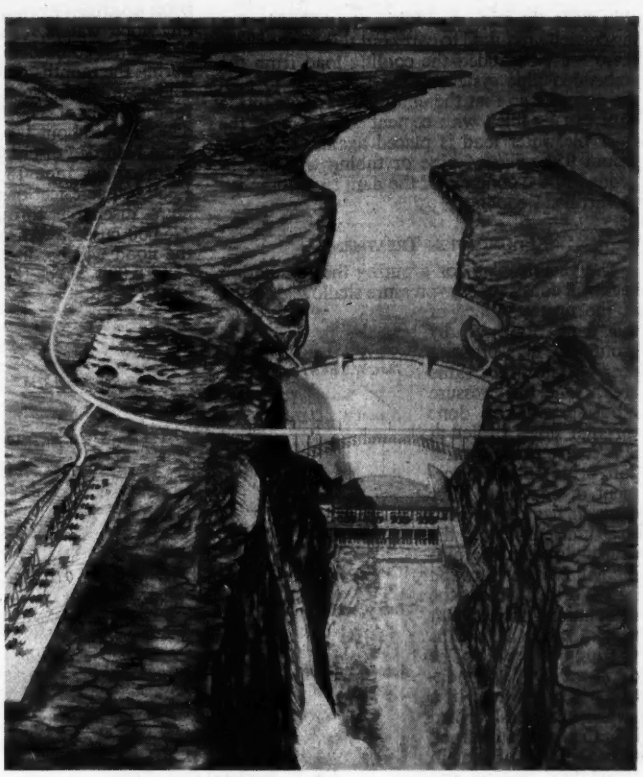


Fig. 1—Artist's impression of Glen Canyon dam, reservoir, power station and Colorado River bridge

The Glen Canyon dam is to be about 700ft high above its foundation—second in height only to the 726ft high Hoover dam—and will be built on the Colorado River in north-central Arizona, about 15 river miles upstream from Lees Ferry and 12 river miles downstream from the Arizona-Utah state line. It is about 370 miles upstream from the Hoover dam on the Lower Colorado River. The Glen Canyon dam is designed to serve multiple purposes by creating a reservoir for conservation storage, power generation, silt retention, recreation and fish and wildlife conservation. It will be a concrete arch structure having a volume of 4,770,000 cubic yards, a crest length of 1500ft and a maximum thickness at the base of 300ft. The reservoir will have a capacity of 28,040,000 acre-feet and will extend 186 miles up the Colorado River and 71 miles upstream on the San Juan River. The Glen Canyon reservoir and other storage units in the Upper Colorado River basin will provide hold-over reserves of water to meet the terms of the 1922 Compact of the Colorado River. The Glen Canyon power station, which is to be built concurrently with the dam, has been designed to include an installed capacity of 900MW.

Access Problems

By virtually any construction standard, access to the remote Glen Canyon area imposes major problems in the transport of supplies and equipment from established areas to the site. As an example, although it is approximately 1200ft from one rim of the canyon to the other at the dam site, it was necessary, until recently, for vehicular traffic to go 225 miles to get from one side of the canyon to the other. Flagstaff, Arizona, a railhead, is 135 miles from the dam site; the railhead at Marysvale, Utah, is 200 miles from the dam site, via Kanab, Utah, which is the nearest town.

Initial major construction at the dam site began in October, 1956, following the award of a 2,500,000 dollar contract to the Mountain States Construction Company, of Denver, for the construction of the west diversion tunnel. The 2740ft long tunnel has a diameter of 43ft 6in in its upstream portion and a diameter of 46ft 6in in its downstream portion.

The principal quantities required for the dam, spillway, outlets, and power station are shown in the following table.

Principal Quantities Required for the Dam, Spillway, Outlets, and Power Station

Excavation, common, for dam and power station, cubic yards	985,000
Excavation, rock, for dam and power station, cubic yards	1,650,000
Excavation, all classes, in open cut for spillways, cubic yards	1,325,000
Excavation, all classes, in spillway tunnels, cubic yards	132,000
Excavation, all classes, in diversion tunnels, cubic yards	182,000
Concrete in dam, cubic yards	4,770,000
Concrete in spillway and diversion tunnel lining, cubic yards	110,000
Concrete in appurtenant structures, except power station, cubic yards	155,000
Concrete in power station, cubic yards	157,000
Reinforcement, pounds	28,900,000
Tubing and fittings for grouting, pounds	755,000
Tubing and fittings for cooling concrete, lineal feet	4,650,000
Spillway radial gates and hoist, pounds	1,950,000
Penstock and outlet pipes, pounds	21,000,000
Fixed-wheel gates and hoists for penstocks, pounds	3,180,000
Ring-follower gates and hollow-jet valves for outlets, pounds	1,300,000
Trashrack metal work, pounds	1,880,000
Structural steel for power station superstructure, pounds	4,250,000
All other metal work required for the dam, outlets, spillways, and power station, pounds	5,140,000

Most of the materials listed will be supplied and installed by the general contractor during the period of the contract, which is expected to extend for about seven years. In addition to these materials, the Bureau of Reclamation will purchase the larger items of special machinery and equipment under separate contracts.

Site of Dam

The Glen Canyon covers a 176-mile section of the Colorado River basin from the lower end of the Cataract Canyon, 14 miles above Hite, Utah, to Lees Ferry, Arizona. This canyon is one of the spectacular cuts by the Colorado River. Throughout most of its length, Glen Canyon is a narrow river gorge confined by massive sandstone walls variable in height, the maximum being 1200ft above river level. At Lees Ferry, the lower terminal of the canyon, the nearly vertical walls recede, and the river flows for a short distance in a relatively open valley before entering the narrow gorge of the Marble Canyon. Above the rim of the Glen Canyon and extending for some distance on either side is a gently rolling upland plain dotted with isolated buttes and mesas and cut at intervals by deep narrow canyons leading into the Colorado River. The entire area is a vast expanse of wasteland, uninhabited except for a few ranchers on the north-west side of the river and scattered Indian families on a reservation to the south-east.

The Glen Canyon area is a small but typical part of the Colorado Plateau province, a vast area of nearly horizontal sedimentary rocks that have been elevated without materially disturbing the component layers. It is essentially a country of broad, cliff-edged mesas cut by narrow, steep-walled canyons. The dam site lies in a narrow straight-walled section of Glen Canyon about 1 mile below the mouth of the Wahweap Creek. At this site, the sides of the canyon rise abruptly from the bed of the river in nearly vertical walls 650ft high. Both abutments and the foundation area at the site are in the Jurasic Navajo sandstone. The Navajo formation is a massive, highly cross-bedded, buff to red, medium- to fine-grained sandstone made up essentially of white and pink quartz grains and a few grains of other minerals.

The climate in the vicinity of the dam site is dry. Summers are hot and winters are relatively mild. The maximum recorded temperatures for June and July are 114 deg. Fah., while a minimum temperature of 2 deg. Fah. has been recorded in December and January. Snowfall is light and should not create any construction problem. For

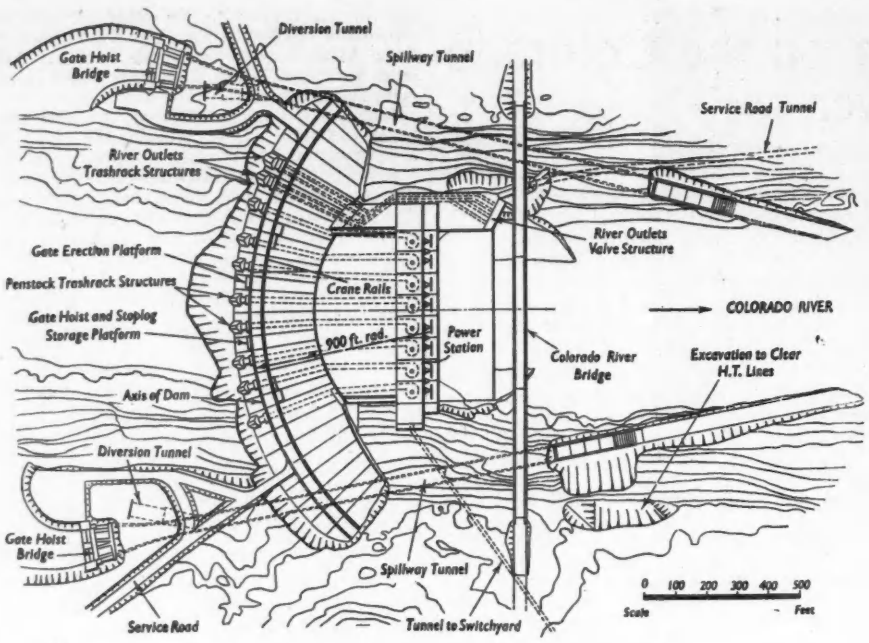


Fig. 2—Plan view of Glen Canyon dam and power station

the past twenty years of record at Lees Ferry the average annual snowfall was about 4in and the annual precipitation was 6in.

Dam Construction

For the construction of the dam, the contractor will be required to erect and maintain a complete concrete plant. The plant will include equipment for processing, conveying, and stockpiling concrete aggregates; storage and handling facilities for both cement and pozzolan; mixing and batching facilities; refrigerating equipment for cooling aggregates and mixing water; and a cable-way or other means of conveying the concrete to and placing it in the dam. The aggregates to be used in the concrete for the dam will probably be obtained from a government-owned property known as the Wahweap deposit, situated on the Wahweap Creek about 7 miles upstream from its junction with the Colorado River. The aggregate will require washing and some wastage to obtain the desired quality and grading. As the aggregates are potentially reactive with alkalis in cement, low-alkali cement will be called for in the dam. It is anticipated that the mass concrete for the dam will contain about two sacks of portland cement and one sack of pozzolan per cubic yard.

The dam is to be divided into columns or blocks by radial and circumferential contraction joints. The blocks will range in size from 55ft by 170ft in the downstream portion at the base to 70ft by 130ft in the upstream portion. To ensure monolithic action of the dam and to secure the desired stress distribution in the structure, the contraction joints will be grouted. For the injection of grout into the joints, a system of pipes is to be embedded in the concrete adjacent to the contraction joints. The contraction joints are to be interlocked by keys formed to provide a maximum cross-sectional area ensuring ample resistance to shear after grouting. The contractor will have the option of placing the concrete in the dam in either 5ft or 7ft 6in lifts. The rate of placing concrete in any block will be restricted so that not more than one horizontal lift can be placed in 72 hours. A maximum vertical difference of 25ft in the top surface of adjacent blocks will be permitted.

The temperature control measures will consist primarily of pre-cooling the various parts of the concrete mix to obtain concrete placing temperatures of not more than 50 deg. Fah. and of artificially cooling the concrete by an embedded pipe system to temperatures of between 40 deg. and 50 deg. Fah. The pre-cooling measures will include cooling the aggregate either by immersion in an ice-water bath or by refrigerated air blasts, cooling the mixing water and by adding slush or chip ice to the mix. In addition to the refrigerating capacity required to carry out this pre-cooling, there must be added the cooling load from the embedded pipe system which is needed to cool the concrete so that the contraction joints in the dam can be filled with cement grout before the reservoir water load is placed against the dam. About 950 miles of pipe or tubing will be embedded in the concrete of the dam to accomplish the artificial cooling.

Foundation Treatment

The general plan for grouting the foundation rock will consist of low-pressure shallow grouting at the upstream face of the dam, followed by grouting a high-pressure deep curtain in the same area. The low-pressure grouting will be done through holes drilled at 20ft centre to a depth of 25ft prior to the placement of concrete. After concrete has been placed to a sufficient height, the deep high-pressure grouting will be done through holes drilled from the foundation gallery at 10ft centres and at depths varying up to 250ft. The drainage of the foundation will be provided by a series of holes drilled into the foundation rock from the floor of a main foundation gallery and from the roof and floor of the foundation tunnels which will extend into each abutment. A second foundation gallery parallel to and downstream from the main foundation gallery will be situated in the dam, and drainage holes will be drilled from this gallery if future foundation drainage conditions require them. The drainage from the foundation galleries will be collected in a sump off the lowest point in the gallery system and pumped out of the dam.

Power Station Construction

The Glen Canyon power station is to be constructed about 470ft downstream from the axis of the dam. It will be a reinforced concrete structure 665ft long, 113ft wide, and 150ft high above foundation. The station superstructure will be a structural steel frame having reinforced concrete enclosure walls. The roof will be built of precast concrete slabs and concrete cast *in situ*. The specifications offer the contractor the alternative of placing either precast panel walls or walls cast *in situ* in the superstructure.

The construction of the power station will be carried out in two stages. First-stage construction, which is part of the prime contract for the dam, includes the placement of 87,000 cubic yards of structural concrete, 10,700,000 lb of reinforcing steel, and 4,250,000 lb of structural steel. In addition, 60,000 cubic yards of mass concrete are to be placed beneath the power station. Second-stage construction, which will be carried out under a separate completion contract, will include the placement of 30,000 cubic yards of concrete and 3,000,000 lb of reinforcing steel. The completion contract, which is to be awarded after the completion of the major portion of the prime contract, will call for the installation of the generating equipment, exposed piping and electrical conduits, architectural finish, heating and ventilating equipment, and other finishing work.

The power station is designed for an ultimate installation of eight 112·5MW generating units. The capacity of each turbine is 155,000 h.p. at a rated head of 450ft. Water will be conveyed to each generating unit through a 15ft steel penstock embedded in the dam. The penstocks emerge at the toe of the dam and span the intervening distance between the toe and the power station on concrete piers.

Hydraulic Design

Spillway tunnels having their entrances about 600ft upstream from the dam will be used to pass any flood waters. The inflow design flood was based on a combination of snow and rain floods during the months of April, May, June and July. The peak discharge is 380,000 cusecs and has a total volume of 29,060,000 acre-feet. This peak discharge is about 1·7 times as large as the maximum recorded discharge of 220,000 cusecs which occurred on June 18, 1921. By storing about 1,850,000 acre-feet of the flood waters, the maximum discharge through the spillways will be 276,000 cusecs. An additional 15,000 cusecs of the flood will be discharged through the outlets and 10,000 cusecs through the four units of the power plant.

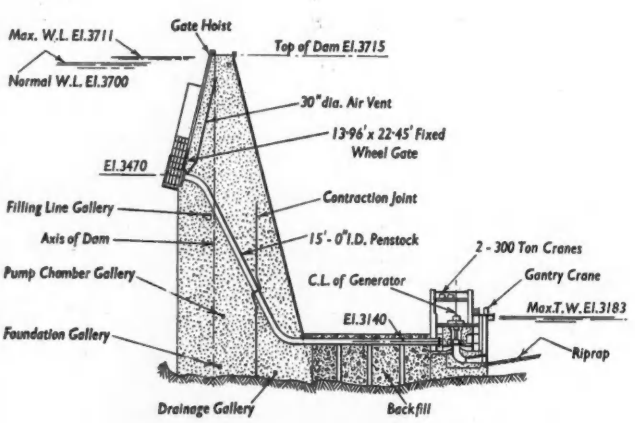


Fig. 3—Sectional view of Glen Canyon dam and power station

The crests of the entrance channels for the spillway tunnels are controlled by two 40ft by 52·5ft radial gates for each tunnel. The tunnels will each be concrete-lined and will have transitions from the crests to 41ft diameter tunnels. The lining of both tunnels is to be done under the dam contract. Ski-jump buckets at the downstream ends of the spillways will raise the water so that it will be deflected into the centre of the river channel. Although the entrance channels of the spillway tunnels will be unlined, the discharge velocities of the water, which will be as high as 162ft per second, will require that the elbow areas have a special finish to minimise cavitation.

The closure of the left diversion tunnel will be in two stages. Initial work will install the first section of the tunnel plug containing three 4ft by 5ft high-pressure slide gates. This will be done during the low-flow season when the flow of the

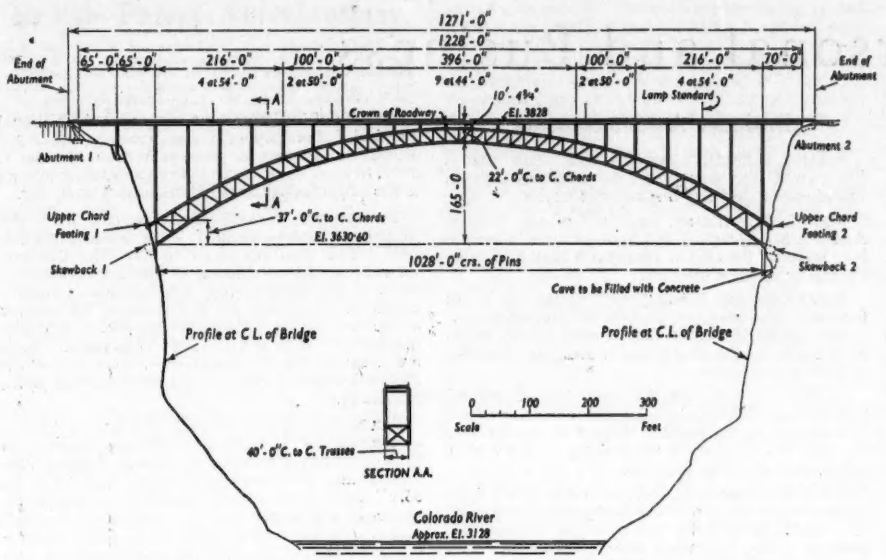


Fig. 4—Elevation of steelwork bridge to be built over the Colorado River at the dam site

river will be confined to the right tunnel. The gates in the plug section will control the discharge downstream and will allow storage in the reservoir to begin when the right tunnnel is closed. The final closure of the left tunnel will be made when the reservoir fills to the level at which the river outlets in the dam can supply minimum downstream releases of 3000 cusecs. At this time, the slide gates will be shut, the gate passages and chambers filled with concrete and the final section of the concrete plug installed.

The closure of the right diversion tunnel will be scheduled in time to store the spring run-off in the reservoir. It is contemplated that a normal spring run-off with minimum downstream releases will fill the reservoir to the minimum power storage level. During the closure the contractor will be required to release 1000 cusecs through his closure structure until sufficient head is available to pass 1000 cusecs through the gates in the left tunnel plug. After final closure at the upstream portal, the construction of the concrete tunnel plug can begin. The river outlets which are situated on the left abutment, will provide river releases for downstream commitments when the power plant is not in operation and when final closure is made of the diversion tunnels. The capacity of the outlets is 15,000 cusecs at minimum water surface elevation. The outlets consist of four 96in steel pipes controlled by hollow-jet valves and have ring-follower gates for emergency closure. The intakes are at an elevation 10ft above the estimated 100 year silt level, and will be protected from trash and debris by concrete trashrack structures on the upstream face of the dam.

From hydrological investigations, the following flood frequencies have been determined in analysing the diversion of the river :

	Peak Volume
5-year flood	118,000 cusecs.
10-year flood	150,000 cusecs.
25-year flood	196,000 cusecs.

	Maximum 15-day Volume
5-year flood	2,723,800 acre-feet.
10-year flood	3,180,000 acre-feet.
25-year flood	3,550,000 acre-feet.

Colorado River Bridge

A striking aspect of the Glen Canyon construction is the Colorado River bridge about 700ft above river level. The bridge, which is to be built 865ft downstream from the axis of the dam, is to be a single-span steel arch, having a rise of arch of 165ft and a length of 1028ft. It will have a reinforced concrete deck comprising a 30ft roadway and two 4ft sidewalks, one on each side of the roadway. The live load design has been based on the loading of a 20-ton truck followed by a 16-ton trailer, in accordance with the latest requirements for the American Interstate Highway System. The concrete foundations supporting the arches are to be placed in sound rock of the Navajo sandstone formation at each canyon rim where geological joints are at a minimum. A 4,000,000 dollar contract for the construction of the bridge has been awarded to the Kiewit-Judson Pacific Murphy Company, of Emeryville, California, and it is expected to be completed early in 1959. Specifications for the bridge call for the contractor to supply and install 8,000,000 lb of structural steel, 250,000 lb of reinforcing steel, 100,000 lb of handrailing, and 1000 cubic yards of concrete in the bridge deck.

To overcome the difficult problems of access to the remote dam site and to ensure a steady flow of materials and supplies for construction, the Department of the Interior entered into an agreement with the State of Arizona which called for the construction and maintenance of a 25-mile access road 34ft wide to the site of the dam and the Colorado River bridge. The agreement with Arizona makes it possible to bring the road up to the standards of a primary highway—beyond temporary construction needs of the Bureau of Reclamation—and is the first step toward a permanent loop off U.S. Highway 89. The highway and bridge will permit ready access to the dam site from presently existing improved highways over which construction materials and equipment will be moved from the railheads. The highway will also provide a tourist route to the scenic recreational area and reservoir to be created by the construction of the dam.

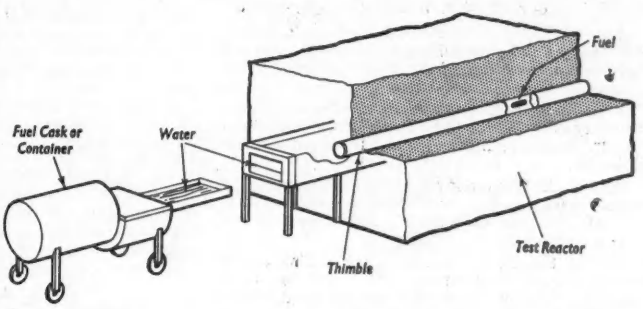
The Bureau of Reclamation has built a temporary access road extending from the Colorado River bridge site on the west side of the river to the Utah-Arizona border. Utah has completed a link of largely unimproved road from the border to Highway 89 at Kanab. Arizona has also completed a temporary road from The Gap on Highway 89, which is being used for access to the east side of the dam site. Because of the remote location of the project from existing towns, it is necessary to construct a complete community near the site.

The contractor may employ about 4000 people at the peak of construction, which would represent a population of about 6000 ; to this would be added a government force of about 500, representing a population of about 2000. Thus the Glen Canyon community will have a total estimated population of about 8000. This town will be similar in many respects to Boulder City, Nevada, constructed in the early 1930s by the Bureau for the Hoover Dam project, except that now private enterprise will be encouraged to develop the community facilities to the fullest extent practicable. The Glen Canyon community will be a modern urban development, having bituminous-surfaced streets, electric street lighting, water purification and sewage disposal systems, a hospital, a school and playgrounds.

Handling of Hot Atomic Fuels

An interesting system for handling "hot" atomic fuels has been developed by the General Electric Company at the Knolls Atomic Power Laboratory in Schenectady, New York. The new equipment is called the "hot reload system" and permits the re-insertion of radioactively "hot" fuel into the "loop facility" of a materials test reactor. The loop facility is used to simulate conditions under which fuel will burn in the power-producing plant for which it is designed. With the "hot reload system" a single sample of fuel may be used through an entire series of experiments, permitting removal and replacement of fuel samples in a test reactor as often as is desirable and with relative ease. Prior to the introduction of the system, a new fuel sample was needed for each test performed. The new equipment makes it possible to halt one test, remove the fuel and insert other materials into the test reactor when "rush order" handling is required. The equipment is now in use at the U.S. Atomic Energy Commission's National Reactor Testing Station at Idaho Falls, Idaho.

As shown in the accompanying illustration, the new equipment reaches into the thimble which is situated in the heart of the test reactor and draws the radioactive fuel out through protective water-filled tanks and into the fuel cask.



Diagrammatic view of "hot" reload system for nuclear test reactor

The fuel is then stored in the cask until it is needed for study or additional tests. The previous system involved removal of thimble and fuel after each test. After removal and tests it was impossible to replace them in the test reactor because the high level of radioactivity made them too "hot" to handle. Because of this, they were destroyed following each test. Now, one thimble and fuel sample may be used through a series of tests lasting for perhaps thirty weeks.

Second World Metallurgical Congress, Chicago

The Second World Metallurgical Congress in Chicago, which is sponsored by the American Society for Metals, will be held from November 2 to 8 and will be immediately preceded by a two-week tour of industrial plants. There will be nine such simultaneous study tours of U.S. metals industries, and the activities covered by these tours will include steel making and refining, non-ferrous refining and fabrication, heat treatment, welding and jointing, inspection and testing, research, management problems in the metals industries and the metallurgical aspects of atomic energy. Plutonium production will be the topic of one of the main sessions.

Both the tours and the technical sessions in Chicago on inspection and testing will form part of the second International Conference on Non-Destructive Testing, which will be concurrent with the metallurgical congress. Further information can be obtained from the American Society for Metals, 7301, Euclid Avenue, Cleveland, 3, Ohio.

Personal and Business

Appointments

MR. LEWIS G. Whyte has been appointed a director of Associated Commercial Vehicles, Ltd.

DR. ALAN J. HAYTER has been appointed a director of Sharples Chemical and Industrial, Ltd.

MR. N. L. G. LINGWOOD has been re-elected president of the British Acetylene Association.

MR. J. MCWILLIAM has been appointed regional manager for Scotland for A.C.V. Sales, Ltd.

MR. H. L. B. CHRISTY has been appointed sales director of the Vaughan Crane Company, Ltd.

MR. JAMES F. WESTAWAY has been appointed works manager to Westool, Ltd., St. Helen's, Auckland.

F. H. LLOYD AND CO., Ltd., has announced that Mr. M. C. Lloyd has been appointed assistant managing director.

MR. ROBERT RITCHIE, northern manager of Klockner Moeller England, Ltd., has been appointed technical director.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has announced the appointment of Mr. N. Pickles as manager of its Lincoln branch office.

MR. A. E. CAIN has been appointed director in charge of the new electronics and instrumentation department of Dekko Cameras, Ltd.

THE WALTER KIDDE COMPANY, Ltd., has announced that Mr. C. C. Hall, Mr. Andrew Smith and Mr. A. R. Spidy have been appointed directors.

THE HAWKER SIDDELEY GROUP, Ltd., has announced that Mr. H. G. Herrington, F.R.Ae.S., and Mr G. C. R. Eley have been appointed directors.

BRITISH OXYGEN CHEMICALS, Ltd., has announced that Mr. Leslie G. D. Sheldrake has been appointed works director, and Mr. J. M. Williams, sales director.

MR. H. NEVILLE DAVIES, press officer to Kelvin and Hughes, Ltd., has relinquished that post, and has been appointed editor of the English Electric house journal.

MR. GEORGE B. CAMPBELL has been appointed secretary of the Radio Industry Council in succession to Mr. Rupert P. Browne, who has retired through ill health.

MR. S. J. WRIGGLESWORTH has been appointed deputy managing director of Oldham and Son, Ltd., and Mr. Orlando Oldham has been appointed his personal assistant.

MR. M. SEAMAN has left the board of directors of British Oxygen Engineering, Ltd., and has been appointed director responsible for equipment manufacture of British Oxygen Gases, Ltd.

MR. P. W. HOWARD, managing director of the British Tyre and Rubber Company, has been elected president of the Research Association of British Rubber Manufacturers in succession to Lord Baillieu. Mr. D. B. Collett has been elected chairman.

THE CANADIAN PACIFIC RAILWAY has announced that Mr. W. D. Dickee has been appointed assistant chief of motive power and rolling stock ; Mr. C. W. Parker, chief mechanical engineer, and Mr. H. W. Hayward, works manager, of the company's Augus shops in Montreal.

THE NORTHERN ALUMINIUM COMPANY, Ltd., has announced that Mr. C. J. Buchanan-Dunlop has been appointed manager of the sales administration division, Banbury. Mr. J. A. Ambler has taken over the newly formed market research section of the sales department, Banbury.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has announced that Mr. R. Clough, superintendent, switchgear department, has been appointed assistant works manager (inventory control). Mr. J. Harwood has been appointed to succeed Mr. Clough as superintendent, switchgear department.

SHARPLES CENTRIFUGES, Ltd., has announced the following appointments :—Mr. W. Maxfield has been appointed senior project engineer (Scotland and Northern Ireland) ; Mr. R. S. Curwen has been appointed senior project engineer (S.E. England), and Mr. F. V. Hooley has joined the head office applications engineering staff.

THE BRITISH TRANSPORT COMMISSION has announced the appointment of Mr. E. G. Marsden as secretary, British Road Services, in succession to Mr. J. L. Willoughby. Mr. P. A. Satchwell has been appointed work study assistant in the manpower adviser's department, work study division. Mr. H. Leyshon has been appointed an assistant (development), operating and motive power department, British Railways central staff, and Mr. B. Reynolds has been appointed signal development assistant, signal engineering department.

Business Announcements

IGRANIC ELECTRIC COMPANY, Ltd., states that it has moved into new offices at 4, Albert Square, Manchester (telephone Blackfriars 8033).

MR. C. W. ARGENT, chairman of the Natural Asphalte Mine-Owners' and Manufacturers' Council, is to leave for the United States on August 8 to study the mastic asphalte industry.

KERRY'S (GREAT BRITAIN), Ltd., states that it has formed a new company, Kerry's (Ultrasonics), Ltd., Tonbridge Road, Harold Hill Trading Estate, Romford, Essex, for the production of ultrasonic cleaning and machining plants.

F. PERKINS, Ltd., Peterborough, has announced that Mr. A. J. Dillingham has resigned from its board of directors, having reached the age of seventy-five, but that his services, in an advisory capacity as a consultant, have been retained.

THE A.P.V. COMPANY, Ltd., states that it has concluded an agreement with the Rosenblad Company of Stockholm, Sweden, for the exclusive manufacture and sale of the Rosenblad heat exchanger in Great Britain. A.P.V. will also be responsible for its sale in the Commonwealth, except Canada, and in the Middle East.

BIRFIELD, Ltd., has announced the formation of a new subsidiary company, Birfield Engineering, Ltd. for the co-ordination of engineering activities among the companies that make up the Birfield group. Mr. G. W. M. Lush has been appointed managing director of the new company, and Mr. D. Bastow, M.I.Mech.E., and Mr. E. J. Rabson, A.M.I.Mech.E., have been appointed directors.

THE HAWKER SIDDELEY GROUP has announced the formation of a ninth company in the A. V. Roe Canada, Ltd., group. Entitled Canadian Thermo Control Company, Ltd., it has been established to sell and service refrigeration equipment under a licence agreement with Thermo King Corporation and Thermo King Railway Corporation of Minneapolis, Minnesota. Mr. Crawford Gordon, Jr., has been appointed chairman of the new company. It was announced last week that the Hawker Siddeley Group, Ltd., and John Brown and Co., Ltd., are to form a new company to be known as Hawker Siddeley John Brown Nuclear Construction, Ltd., with Sir Roy Dobson as chairman. The company will deal with the problems of nuclear power as applied to marine propulsion and other nuclear projects.

Contracts

FOSTER-WHEELER, Ltd., has been awarded a further contract by the Iraq Government Oil Refineries Administration for the expansion of the Daura refinery. The value of the contract is approximately £3,700,000 and the work will be completed within two years. The new equipment includes a crude unit, catalytic reforming unit, acid treating unit, 2000kW turbo-alternator, cooling water tower and circulating pump and storage tanks, together with interconnecting piping.

TAYLOR WOODROW CONSTRUCTION, Ltd., has received a contract from the Somerset County Council for the construction of the access road from Cannington, near Bridgwater, to the site of the proposed nuclear power station at Hinkley Point. The contract involves the widening and improvement of existing stretches of road, together with the construction of new sections, including bridges and culverts, to provide nearly 6 miles of road. Work is starting at once and the contract period is six months.

Miscellanea

MECHANISED PREPARATION OF STEEL SECTIONS.—A fully mechanised plant for cutting off, drilling and delivering structural steel sections, installed in the Norwich works of Boulton and Paul, Ltd., was described in our issue of June 19, 1953. The success of the original plant has been such that it is now to be marketed both in this country and abroad to fabricators of steel structures. A film, " Structural Steel at Our Fingertips," showing the plant in action, is available from the firm.

RUTHERFORD MEMORIAL APPOINTMENTS.—Under the terms of the scheme to commemorate the late Lord Rutherford of Nelson, the Council of the Royal Society has appointed Professor E. N. da C. Andrade, F.R.S., as Rutherford Memorial Lecturer for 1957, to deliver the lecture in Australia during September-October. Professor P. M. S. Blackett, F.R.S., has been appointed for 1958, to deliver the lecture in Canada. Mr. S. L. Surange, a graduate of the University of Lucknow, now working at the National Physical Laboratory of India, has been appointed Rutherford Scholar for three years from October 1, 1957, to carry out research in low temperature physics at the Royal Society Mond Laboratory, Cambridge.

TWENTY-FIVE YEARS' RESEARCH ON TIN.—An illustrated booklet entitled " Tin Research, 1932-1957 " has been published by the Tin Research Institute at the completion of the first twenty-five years of the International Tin Research Council's existence. Written by Dr. E. S. Hedges, the director of the Institute, the booklet reviews the development of the organisation and the results of its work. Copies are available free of charge on request to the Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex.

WELDING OF THICK PLATE.—The development of an electrode for the welding of plates up to 3in or 4in thick has been announced by Murex Welding Processes, Ltd., Waltham Cross, Herts. The " Fortrex 35A " electrode is claimed to give all the required properties in the joint, with particularly good impact characteristics at low temperatures. Research leading to this development involved the testing of a large number of 3in to 4in plates over many months, and about a thousand Charpy V-notch test pieces were machined from the welds.

INTERNATIONAL CONCRETE ROAD CONGRESS.—The pavings development group (concrete and soil-cement) of the Cement and Concrete Association is organising a visit to Rome this year to the International Concrete Road Congress, which is being held from October 16 to 19. The congress, which is the first of its kind ever to be held, has been arranged by the Cement and Concrete Associations of many European countries with the support of leading organisations connected with the use and development of roads and the Italian Government.

LAMINATION DETECTOR.—We learn that the B.I.S.R.A. lamination detector for use in the inspection of steel sheet is now being produced under licence by the Ultrasonoscope Company, Ltd., Sudbourne Road, Brixton Hill, London, S.W.2. The device makes use of the fact that a discontinuity such as a lamination modifies the path of an electric current through the sheet. Two pairs of silver steel discs on sprung mountings are made to traverse back and forth across the sheet. The discs provide the contacts to carry the current and measure the potential difference. It is stated that strip 0·020in thick was inspected while moving at 300ft per minute in a laboratory rig, and that laminations ½in wide were satisfactorily detected.

HOT-STRIP WIDTH METER.—An invention of the British Iron and Steel Research Association, a hot-strip width meter, has now become available commercially. It is being made by two companies, Evershed and Vignoles, Ltd., Acton Lane Works, Chiswick, W.4, and the Davy-United Engineering Company, Ltd., Park Iron Works, Sheffield, 4. Infra-red radiation from the hot strip is detected, and servo-operated shutters " follow " the edges of the strip to control the amount of radiation falling on photo-electric cells. Temperature variation in the strip is taken into account, and the instrument is claimed to indicate width with an accuracy better than $\pm \frac{1}{16}$in over a range of 6in. A change in width is registered in less than 0·15 second.

COMMITTEE FOR NON-DESTRUCTIVE TESTING.—At the beginning of this year a combined appeal was made by a number of societies to the Joint Committee on Materials and their Testing to foster the establishment of a National Committee as a focus in the United Kingdom for all interested in non-destructive testing. The Joint Committee accordingly set up a sub-committee to examine the request and, as a result of its recommendations, it has approved the constitution, terms of reference and rules for a committee which will be known as The British National Committee for Non-Destructive Testing. The formation, at this time, of a British National Committee for Non-Destructive Testing is of considerable significance, particularly in view of the coming international conference in Chicago in November. Applications for membership of the British National Committee are invited from institutions or societies with an interest in non-destructive testing. The subscription is five guineas per annum. Each member society will be asked to nominate a representative who would take part in meetings of the national committee. Applications, for the time being, should be made to the Secretary of the Joint Committee on Materials and their Testing, Mr. R. Main, A.M.I.Mech.E., at 1, Birdcage Walk, Westminster, London, S.W.1. Pending an election, the chairman of the British National Committee will be Mr. C. H. Stanger, A.M.I.C.E., A.I.Struct.E.

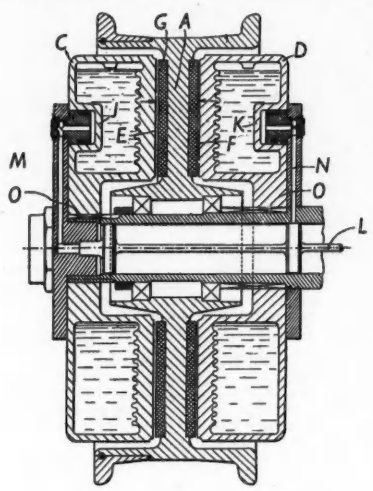
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

AIRCRAFT BRAKES

778,336. May 23, 1955.—THE COOLING OF BRAKES, Societe d'Inventions Aeronautiques et Mecaniques S.I.A.M., 1, route des Alpes, Fribourg, Switzerland.

The invention comprises improvements in or relating to the cooling of brakes. In the technique of braking a number of constructions have already been proposed or applied to ensure the dissipation of the kinetic energy of the machine to be braked, and this is especially the case with aircraft of heavy tonnage, or those which land at high speed. According to the invention, a brake of high calorific capacity, mounted on a wheel assembly, comprises in combination two annular chambers mounted on a fixed portion of the wheel assembly, each chamber having at least one wall in a plane perpendicular to the axis of rotation of the wheel, one or more brake discs mounted, for rotational movement with the wheel, so as to be capable of frictional engagement with one of the walls of each chamber, a substance of high calorific capacity in each of the chambers, and means to produce relative axial displacement between the two chambers and the brake disc or discs so as to apply or release the brake. The filling liquid may be water or saline



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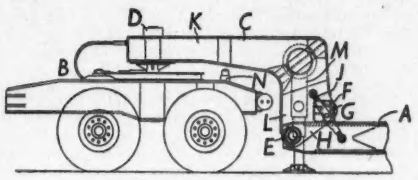
solutions or glycols or other liquids not very liable to freeze and not very inflammable. Amongst coolants particular reference may be made to bismuth and its alloys and sodium and its alloys. The body of the brake may be made of copper, or of the alloys of aluminium or of magnesium. The parts in frictional contact may be surface hardened by chromium-plating. For the brake shoes, friction linings of the material sold under the trade name of " Ferodo " or similar material may be employed. In the form of embodiment shown in the drawing, the disc is a central web *A* of the wheel itself. The annular chambers *C* and *D* are both movable axially, and in consequence so are also their respective friction plates *E* and *F*, which co-operate with the friction linings *G*, the latter being in this case directly fixed on opposite sides of the web *A* of the wheel. The axial displacement of these annular chambers is controlled by two series of hydraulic actuator units *J* and *K*, which are coupled to a common supply *L*, *M* and *N*. The keys providing for the axial sliding motion of the annular chambers are shown at *O*.—*July* 3, 1957.

ROAD TRANSPORT

778,055. November 26, 1952.—TRAILER ROAD VEHICLES, R. A. Dyson and Co., Ltd., Joseph Dyson and Reginald Joseph Rippon, all of 76–80, Grafton Street, Liverpool, 8.

The invention concerns trailer road vehicles such as are used for transporting heavy loads, of the type comprising a trailer chassis or bed having secured at both ends so-called cranks or " swan-necks." It seeks to provide an improved arrangement for raising and lowering the trailer chassis or bed. In the drawing a trailer road vehicle is shown including a chassis or bed *A* secured to an end supporting bogie generally indicated at *B* by means of a crank or " swan-neck " comprising two angled frames *C*. The actual connection of the crank to the bogie is by way of a kingpin *D*. For securing the chassis or bed to the cranks, there is provided an arrangement consisting of a pivot pin *E* located at a lower point of each angled frame *C*, and a compression block *F* eccentrically rotatable about a mounting pin *G* carried by the angled frame *C*. Rotation of the compression blocks *F* provides differing distances between the axis of pin *G* and an abutment surface *H* presented by the chassis or bed *A*, and, hence, allows alternative angular dispositions between the crank and the bed, whereby the height of the latter above the road surface may be varied. A tensioning element such



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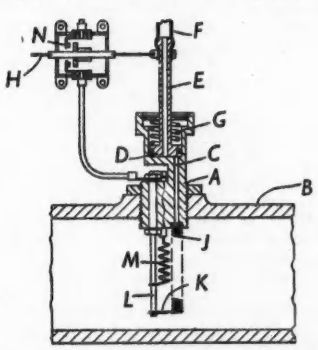
as a turnbuckle *J* is preferably provided to prevent relative movement between the chassis or bed and the cranks in the event that the trailer rebounds after passing over a bump in the road surface. In accordance with the invention, preferably at the junction between the horizontally extending portion *K* and the vertically extending portion *L* of each crank, there is connected a hydraulically or otherwise operated lifting jack *M*, whereby, subsequent to lowering of the chassis or bed to the ground and its disconnection from the crank, said crank may be raised, leaving the bed resting on the ground. A crank support, in the form of a further jack *N*, may then be operated to retain the crank in the raised position, the jack *M* may be lifted, and the crank, on its supporting bogie *B*, withdrawn from the chassis or bed *A* to facilitate loading. The jack *N* is preferably disposed beneath a mid-region of the horizontally extending portion *K* of the crank. More particularly, in operation, the cranks may be detached by lowering the jacks *M* to the floor and removing the turnbuckles *J* applied across the compression blocks *F*, when the latter may be manually rotated to the lowering position. The chassis or bed may then be lowered to the ground by lowering jacks *M*, after which the crank is again raised slightly to free the detachable pivot pin *E* for removal. The jacks *N* on bogie *B* are then raised to take the weight of the crank, and thereafter jacks *M* are raised clear of the ground, when the bogie may be towed clear for loading of the chassis or bed. Preferably each crank is fitted with locating means such as shaped stops or shaped raised plates adapted to engage with complementary stops or plates on the chassis in order to facilitate lining up of the bores for inserting pins *E*.—*July* 3, 1957.

INTERNAL COMBUSTION ENGINES

778,241. January 22, 1955.—AIR HEATING MEANS FOR ENGINES, C.A.V., Ltd., Warple Way, Acton, London, W.3. (*Inventors: Richard William Ridel and Thomas Curzon.*)

The invention has for its object to provide in a simple and convenient form an air heating means for facilitating the starting of an internal combustion engine to which the fuel is supplied by pump injection. Referring to the drawing, the construction comprises a metal body part *A* screwed into a hole formed in



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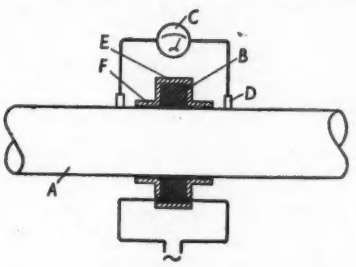
one side of the air intake manifold *B*. In this is formed a longitudinal bore *C* through which can be supplied the liquid fuel required for heating the air flowing along the manifold. In a cavity formed in the outer end is contained a valve in the form of a disc *D* from which extends a hollow stem *E* to which a fuel supply pipe *F* can be attached. The disc is held in contact with the flat base of the cavity by a spring *G* and the passage in the stem is out of line with the bore in the plug, so that the disc, by contact with its seating, can prevent flow from the stem to the body part. To enable the fuel to flow to the body part, the valve is tilted on its seating by manual movement of the stem, through the medium of a cable *H*. In line with the inner end of the bore in the plug is mounted a helically coiled wire *J*, this being connected at one end to the plug, and at the other end to a short arm *K* extending from a metal rod *L* which is inserted through and electrically insulated from the plug, the outer end of the rod serving as a terminal for connection to an electric current supply circuit. Alongside the coil *J*, and in parallel connection with it, is mounted a second coil *M*, this being connected at one end to the body part and at the other end to the rod. Alternatively, the coils may be connected in series. The two coils are such that the first *J* can be heated sufficiently to effect vaporisation of the fuel flowing through it from the body part, the second *M* being such that it can be heated to incandescence for igniting the vapour issuing from the first coil. Any convenient switch *N* is provided for controlling the current supply to the coils, the movable member of the switch being preferably connected to the cable *H* so that actuation of the valve is accompanied by actuation of the switch. On opening the valve, and concurrently closing the switch, a small stream of fuel passes to the vaporising coil, where it is vaporised. The vapour carried forward by the incoming air then passes over the other coil and is ignited. The resulting flame is maintained so long as the valve is held open, and the heat generated preheats the air passing to the engine sufficiently to ensure easy starting of the engine. After the engine has been started, the air heating means is put out of action by closing the valve and opening the switch. Modified designs are also shown in the specification.—*July* 3, 1957.

ELECTRICAL ENGINEERING

778,024. September 14, 1955.—MEASURING TORSIONAL STRESS IN A CYLINDRICAL BODY OF MAGNETOSTRICTIVE MATERIAL, Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden.

The invention relates to a device for measuring the torsional stress in a cylindrical body of magnetostrictive material, such as a rotating steel shaft. It is based upon the fact that a magnetic flux generated in the surface of a cylindrical body is subject to a deformation, if the body is exposed to a torsional stress. In the drawing *A* is the shaft and *B* the winding fed by alternating current, *C* a measuring instrument and *D* contact brushes sliding against the shaft. The brushes are in contact with the shaft outside the flux



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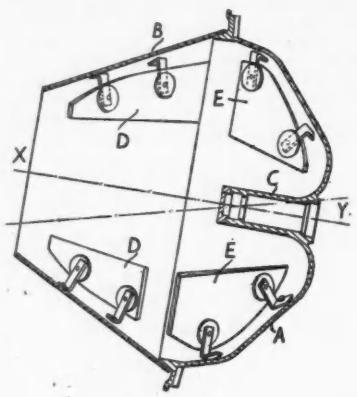
generated by the alternating current winding. This is achieved by surrounding the field-generating alternating current winding by a shell of magnetic material *E*, which prevents a dissipation of the magnetic field. The shell is provided with collar-shaped pole shoes *F*, which surround the shaft with a small play. As long as the shaft is not exposed to any stress, the magnetic flux generated by the winding *B* will, between the pole shoes *F*, run axially in the surface layer of the shaft, but when the shaft is exposed to a torsional stress, the flux is deformed so that the flux lines in the surface layer of the shaft will form helical lines, so that there will be a component of the flux in the surface layer of the shaft running tangentially to this shaft. There will, in other words, be an annular magnetic flux in the surface layer of the shaft. This flux will traverse the loop formed by the shaft between the brushes *D* and the conductors to the measuring instrument *C*. The current induced in the loop will, of course, be proportional to the flux which is embraced by the loop and will thus be proportional to the torsional stress to which the shaft is exposed. It is immaterial in this device whether the brushes make contact with the shaft on the same generatrix. In reality they may be in contact with the shaft at any point, and in order to ensure a permanent good contact, each pole of the measuring instrument may be connected with two or more parallel-connected brushes. In this form it is also possible, in order to ensure a good contact, for the brushes to be in contact with slip rings attached directly to the shaft. In addition to the direct measurement of the torsional stress the invention may also advantageously be used in cases where a regulation of the torque transmitted by the shaft is of importance.

The invention is thus applicable for instance in cases where it is desired to distribute the load on two or more machines driven by the same motor, such as in driving wood pulp grindstones.—*July* 3, 1957.

CONTRACTORS' PLANT

778,322. February 25, 1955.—CONCRETE MIXERS, Stothert and Pitt, Ltd., Bath Somerset. (*Inventor: Norman Edward Kerridge.*)

In concrete mixers one of the problems with which the operator is constantly faced is that each time a batch of concrete is discharged from a revolving mixing drum a small deposit remains on the interior surface of the drum and also on the blades or the buckets. The present invention is concerned with what is known as a free-fall mixer wherein the mixing action is obtained by relatively stationary buckets or blades fixed to the interior of the drum and as the drum revolves the weight of the material being mixed causes it to pour from the buckets or blades when they reach the upper portion of the drum. In this type of mixer its range of usefulness has hitherto been restricted since it is dependent upon the mix being sufficiently wet to enable it to flow sufficiently freely. The invention overcomes this difficulty by constructing the blades or buckets of flexible material, such as rubber, whereby they are capable of flexing



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substantially when under load, and by fixing the blades or buckets to the inside of the periphery of the mixing drum with the major portion of each blade or bucket extending inwards towards the centre of the drum so as to permit deflection of individual blade or bucket elements due to variation in their effective loading as the drum revolves. Referring to the drawing there is shown a revolving drum tilting mixer, the drum comprising a head section *A* and a conical portion *B*, the head including a hollow spigot *C* by means of which it is mounted to rotate, the spigot in accordance with standard practice being capable of angular adjustment from the mixing and rotating axis indicated by the lines X—Y through the horizontal to a suitable angle where the contents are discharged by gravity. The action of this mixer is that, due to the direction of rotation, a pair of blades *D*, *E* carries material up towards the top of the drum where it is cascaded to the bottom and again lifted by the oncoming set of blades. In accordance with this invention, by forming the blades *D* and *E* of thick sheet rubber, the blades will assume a different shape when carrying the load of material and spring back to normal when it is discharged, the discharged material falling on to another set of blades, thus causing them to deflect and rectify themselves with a flicking action, thus speeding the mixing action and ridding the blades of "build up." Here again the flexible blades reduce the "build up" on the inside of the drum shell.—*July* 3, 1957.

Launches and Trial Trips

SALAMA, lighthouse and buoyage tender ; built by Philip and Son, Ltd., for the Government of Zanzibar; length overall 149ft 6in, length between perpendiculars 135ft, breadth moulded 28ft, depth moulded 13ft ; four passengers ; electric deck machinery ; two British Polar Mark M.441 diesel engines, each 310 b.h.p. Launch, May 28.

ALAN EVELYN, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for the British Oil Shipping Company, Ltd.; length overall 661ft 7in, length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in, draught Lloyd's summer freeboard 34ft 2½in, deadweight 31,710 tons, loaded trial speed 15½ knots ; thirty cargo oil tanks, one main cargo pump room, four 900 tons per hour centrifugal turbine-driven pumps, four 150 tons per hour stripping pumps ; two 550kW, 450V, 60 c/s turbo-alternators, one 200kW diesel-driven alternator; one set of Metropolitan-Vickers double reduction geared turbines, 12,500 normal s.h.p. at 105 propeller r.p.m., 13,750 maximum s.h.p. at 107 propeller r.p.m., two Foster-Wheeler "D" boilers provide steam at 600 lb per square inch and 850 deg. Fah. Trial, May 28.

CARRONBANK, cargo liner ; built by Harland and Wolff, Ltd., at Belfast for Andrew Weir and Co., Ltd.; length between perpendiculars 450ft, breadth moulded 62ft 6in, depth moulded to upper deck 38ft 6in, gross tonnage 6300 ; five cargo holds, one 25-ton, two 10-ton, twelve 5-ton, and two 3-ton derricks, electric winches ; three 175kW diesel-driven generators ; Harland and Wolff two-stroke, single-acting, opposed-piston diesel engine, six cylinders, 620mm diameter by 1870mm combined stroke, 118 r.p.m. Launch, May 30.

HANETIA, oil tanker ; built by Smiths Dock Company, Ltd., for Shell Tankers, Ltd.; length between pendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,150 tons on 29ft 8in draught, service speed 14½ knots ; thirty-three cargo oil tanks, one main cargo pump room, four 400 tons per hour turbine-driven cargo pumps, two stripping pumps ; two 550kW turbo-alternators, one 200kW diesel-driven alternator ; one set of Hawthorn, Leslie double reduction geared turbines taking steam at 500 lb per square inch and 800 deg. Fah. from two Foster-Wheeler "D" boilers. Launch, May 30.

HAMINELLA, oil tanker ; built by Smiths Dock Company, Ltd., for Shell Tankers, Ltd.; length overall 557ft, length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,193 tons on 29ft 9½in draught, service speed 14½ knots ; thirty-three cargo oil tanks, one main cargo pump room, four 400 tons per hour cargo pumps, and two stripping pumps ; two 550kW turbo-alternators, one 200kW diesel-driven alternator ; one set of Hawthorn, Leslie double reduction geared turbines supplied with steam at 500 lb per square inch and 800 deg. Fah. from two Foster-Wheeler "D" marine boilers. Trial, May.

Technical Reports

Saunders-Roe "Princess" Flying Boat "G-Alun" Engineering Appraisal. A.R.C. Current Paper No. 280. H.M. Stationery Office. Price 5s. The total flying time of the aircraft was ninety-six hours fifty minutes, and therefore only a limited engineering appraisal is possible. Assessments are, however, given of most of the main installations provided, as well as of ease of launching, beaching and maintenance. Full reports on each of the main installations have been prepared by Saunders-Roe. The various aircraft systems and services are briefly described and assessed where possible, and items requiring further development and investigation are discussed. The general conclusions are that the launching and beaching facilities are satisfactory and that few difficulties are likely to be encountered with any of the installations. A number of detailed recommendations are made.

Report on the Possibility of Creating a Free Trade Area in Europe. Prepared for the Council of OEEC by a special working party. Paris : The Organisation for European Economic Co-operation, 2, Rue André-Pascal, Paris (16e). Obtainable from H.M. Stationery Office, P.O. Box 569, London, S.E.1. Price 3s. The present report is the work of a committee appointed in July, 1956, to study the possible forms and methods of association, on a multilateral basis, between the Customs Union proposed by six members of OEEC and members of OEEC not taking part in that Customs Union. The report is to be submitted to the OEEC Ministers in the first half of February.

Amerikanische Kältetechnik. By R. Plank. Karlsruhe : Verlag C. F. Müller. Price DM.4.—This publication contains the report of a lecture and study tour in the United States, which Professor Plank carried out in 1955/56. The contents deal with five aspects of low temperature technology. In Part I, a description is given of an apparatus for maintaining temperatures between 1 deg. K and 0·25 deg. K, which makes use of the adiabatic demagnetisation of a paramagnetic salt and of superconductivity and its dependence on a magnetic field. Part II describes absorption refrigerating plant for air conditioning, while Part III is concerned with the application of turbo-compressors. The remaining two sections deal with quick-freezing equipment and with refrigerating plant for railway goods wagons.

British Standards Yearbook, 1957. British Standards Institution, 2, Park Street, London, W.1. Price 15s.—This valuable reference work for all users of British Standards lists some 3000 standards and Codes of Practice current on January 1, 1957. It also gives details of the British Standards Institution and its services, with notes on the "kite" mark of approval and the standards to which it applies. Particulars are also given of the Canadian "Approvals" service, whereby electrical gear can be approved for export to Canada before leaving this country. Another useful feature of the book to overseas users is the inclusion of lists of addresses both in this country and abroad, where complete reference sets of British standards can be consulted. The way in which all the standards are listed according to subject in a comprehensive index at the end of the yearbook saves much time and trouble when seeking information on any particular subject.

Surge Recording at High Street (Manchester) 33kV Substation (Ref. S/T78). By E. L. White. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 21s., postage 6d.—E.R.A. reports S/T64 and S/T65 describe statistical investigations of surges at 132kV substations during normal service. The new report describes a similar investigation carried out at a substation on a 33kV system with cable feeders. In eight months, the system voltages were supervised for approximately 5000 hours, during which time thirty-six records were obtained on the E.R.A. surge recorder. The maximum voltage to earth recorded was 267 per cent of the normal peak voltage, which occurred at the terminals of a bank of single-phase transformers when they were de-energised. This switching operation was found to exhibit current chopping in the oil circuit breaker. Three records of fault conditions were obtained, and an analysis of over-voltages on the sound phases due to a single earth fault was made with the help of the E.R.A. network analyser. It was shown that the transient voltages occurring at the incidence of two of the recorded faults could be accounted for. The third fault was assumed to be a double earth fault.

Catalogues and Brochures

FIBREGLASS, Ltd., St. Helens, Lancs.—Leaflet and price list giving details of the type "R.50" air filter units.

MUIRHEAD AND CO., Ltd., Beckenham, Kent.—Folder describing a compensated control system for ship stabilisation.

TUBE INVESTMENTS, Ltd., The Adelphi, London, W.C.2.—Technical report dealing with irradiated polythene tape.

RANSOMES AND RAPIER, Ltd., Waterside Works, Ipswich.—Leaflet giving technical details of the "6 and 7 Fast Standard" mobile cranes.

PEGSON, Ltd., Coalville, Leicestershire.—Illustrated folder describing the "Pegson Telsmith Super-Scrubber" washing machine for stone, gravel, sand and other materials.

B. ELLIOTT AND CO., Ltd., Victoria Works, Willesden, London, N.W.10.—Booklet containing technical details of items of equipment primarily for use on "Victoria" milling machines.

ROBERTSON THAIN, Ltd., Ellesmere Port, Wirrel, Cheshire.—"Ventilation Data Book," giving information on the exhaust capacities of various kinds of ventilators, and details of ventilation schemes employing extractors and inlets to the best effect.

HEADLAND ENGINEERING DEVELOPMENTS, Ltd., 164-168, Westminster Bridge Road, London, S.E.1.—Leaflet describing a tapping attachment capable of converting a standard drilling machine into a tapping machine for thread production from 0B.A. to 10 B.A. in plastic, brass, copper, aluminium.

THE ENGLISH ELECTRIC COMPANY, Ltd., Queens House, Kingsway, London, W.C.2.—Illustrated publication describing a range of steel barrel motors with outputs up to 150 h.p. Specifically designed for mining conditions, the motors can be built either straight, totally-enclosed or totally-enclosed fan-cooled, suitable for any supply voltage up to 650V.

KODAK, Ltd., Kodak House, Kingsway, London, W.C.2.—Leaflet describing glazing machines. Three different machines are dealt with, the model "24TC" with a capacity of 1000–1500 2½ × 3½in prints per hour ; model "15TC," capacity 500–600 2½ × 3½in prints per hour, and the flat bed glazer, model "2," for the smaller studio. Glazing on this model is performed by the use of one 14 × 20in or two 10 × 14in polished stainless steel plates.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Metals Division, P.O. Box 216, Birmingham, 6.—Booklet entitled "Integron High-fin and Low-fin Tubing," giving details of an extended surface tube, processed from one piece of metal, the fins being extruded from a portion of the tube wall by rotary cold forming. The various forms described are intended to give suitable area ratios for heat exchange applications in which the inside coefficient is appreciably higher than the outside.

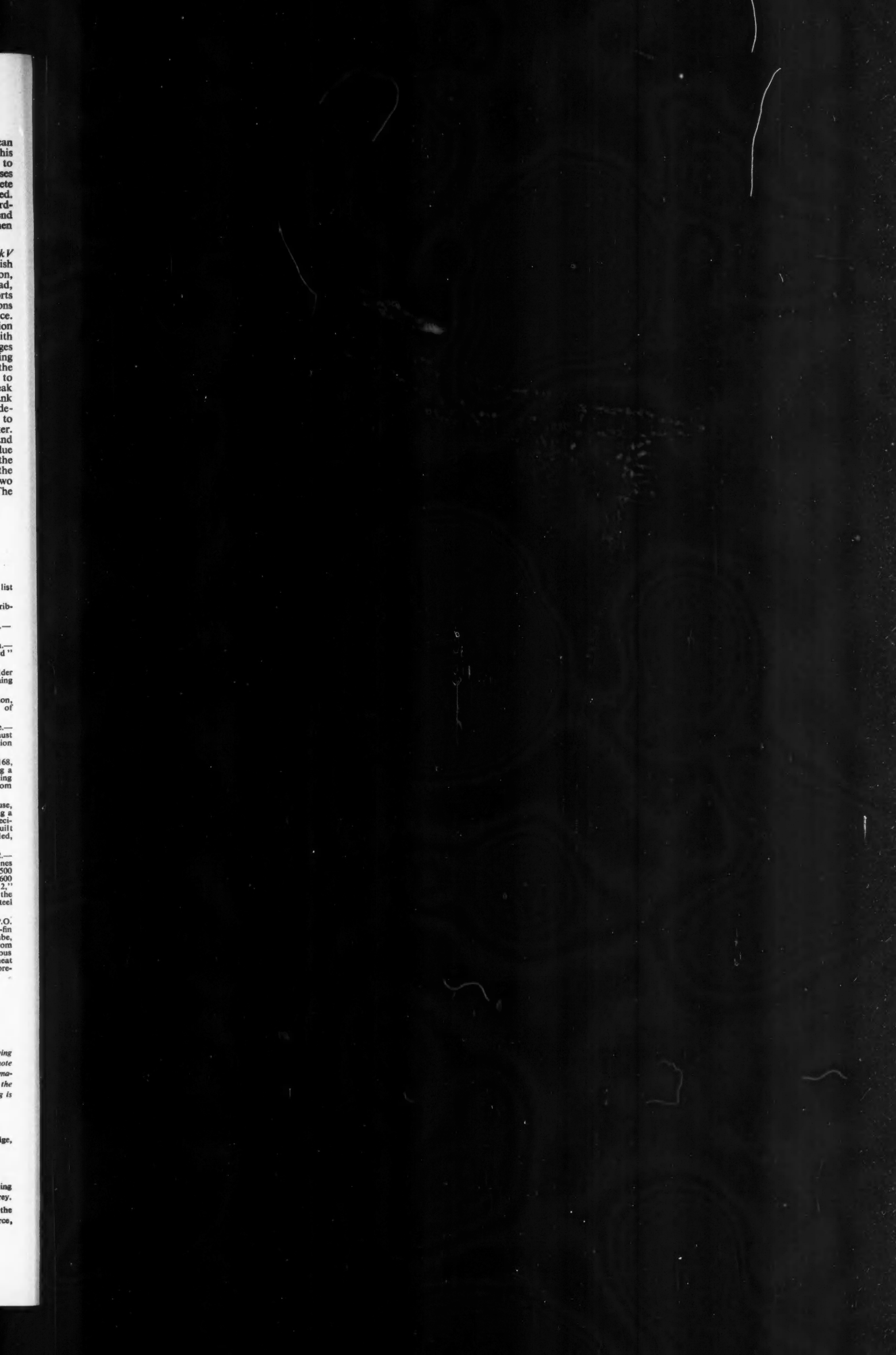
Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTE OF THE MOTOR INDUSTRY

Sat. to Sat., Aug. 24 *to* 31.—St. Catharine's College, Cambridge, Eleventh Annual Summer School.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Aug. 31.—S. BRANCH : Whole-day visit to the pumping stations of the Mid-Wessex Water Company, Frimley, Surrey.

Sat., Sept. 14.—SOUTHERN BRANCH : Whole-day visit to the Greenham Common base of the United States Air Force, Newbury, Berks, 10 a.m.